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Billings, Montana Urban Transportation Plan

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BILLINGS, MONTANA
URBAN TRANSPORTATION PLAN

Prepared for
MONTANA HIGHWAY COMMISSION
PLANNING SURVEY SECTION
and
BILLINGS-YELLOWSTONE
CITY-COUNTY PLANNING BOARD

In Cooperation With
U.S. DEPARTMENT OF
TRANSPORTATION

FEDERAL HIGHWAY
ADMINISTRATION

BUREAU OF PUBLIC ROADS

By
CLARK, COLEMAN & RUPEIKS, INC.
and
DE LEUW, CATHER & COMPANY

April, 1969

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

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Clark · Coleman · Rupeika, inc

* planning * economics
* engineering * research

April 30, 1969

Montana Highway Commission
Helena, Montana 59601

Gentlemen:

We are pleased to submit herewith a summary of the surveys, methodology, findings and recommendations pursuant to our assignment to conduct a comprehensive study of future needs for the street and highway system in the Billings Metropolitan Area. This report presents a long-range plan for a highway network including freeways, major arterial and collector streets, together with an estimate of needed parking capacity in the Central Business District.

The transportation survey provided an accurate basis for estimated future traffic demands and included such items as a comprehensive origin-destination survey, traffic volume counts, screenline counts and parking inventory in the Central Business District. The analysis of this data resulted in a series of mathematical relationships that tended to "explain" the motivation of travel in the Billings area. These basic relationships, when applied to the projected population, land use and other data, enabled us to make a rational estimate of future traffic demands on the street and highway network. After having determined the future travel desires for the study area, a systematic testing of various improvements was pursued and the results evaluated. The proposed alternatives were evaluated in terms of traffic sufficiency with equal emphasis given to such considerations as compatibility with the Comprehensive Plan, public acceptance and financial feasibility. In order to assess these factors it was necessary to produce a number of preliminary designs for the more important features; these plans are included in this report.

Finally, a recommended plan was developed through a series of working meetings with policy making groups responsible for the review of all future plans in the Billings Area.

The expenditure required to implement the recommended program may seem formidable; however, there are numerous far-reaching benefits which warrant its implementation. There are direct benefits to motorists through the reduction in time and operating expense. There will be an improvement in traffic safety through the use of such proven features as one-way operation, limited access facilities and better channelization. There will also be an enhancement of property values through the increased accessibility afforded by an improved transportation network. A more

efficient highway system will also contribute to the development of commerce and industry throughout the Billings area. It is our conclusion that the benefits derived from the improved highway transportation network will exceed its costs by a margin more than sufficient to justify its implementation.

During the course of this assignment we have worked closely with the Montana Highway Commission staff, the Technical Advisory Committee, the City-County Planning Board and the City Engineer. We take this opportunity, therefore, to express our appreciation for the fine assistance and cooperation afforded us by all. The opportunity to participate in the solution of these most important problems is sincerely appreciated. It is our hope that this report, together with your Comprehensive Plan, Transit Report and Signalization Study, may assist in the inauguration of a most significant era in the orderly development and growth of the Billings region.

Respectfully submitted,

DE LEUW, CATHER & COMPANY

Harry E. Lloyd
Harry E. Lloyd
Senior Vice President

CLARK, COLEMAN & RUPEIKS, INC.

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President

Contents

	Page
SUMMARY	1
Chapter 1	
INTRODUCTION	3
Study Objectives	3
Scope of Studies	3
The Study Area	5
Chapter 2	
THE TRANSPORTATION SURVEY	7
Home Interview Survey	7
Roadside Survey and External Travel	9
Truck and Taxi Survey	11
Chapter 3	
EXISTING TRAVEL CHARACTERISTICS	13
Vehicle Ownership	14
Trip Purpose and Peaking Characteristics	14
Traffic Characteristics	16
Travel Patterns	17
Chapter 4	
DEVELOPMENT AND TESTING OF THE TRAVEL MODEL	19
Trip Generation	20
Trip Distribution Model	22
Chapter 5	
PLAN TESTING AND EVALUATION	27
Critical Areas	28
East-West Flow	28
Fairgrounds Area	28
Central Business District	30
Network Testing	30
Alternate Testing Results	30
Chapter 6	
PRELIMINARY ENGINEERING AND COST DATA	33
Basic Assumptions	34
Preliminary Engineering	34
Design Criteria	34
Cost Data	34
Chapter 7	
RECOMMENDED NETWORK	37
Western Area, North-South Facilities	39
Western Area, East-West Facilities	41
The Central Area	42
Billings Heights	43
Montana State Highway 3	43
Additional Access to Interstate 90	44
Railroad Relocation	47
Additional Projects Investigated	47
Chapter 8	
FINANCING	53
City of Billings	53
Yellowstone County	53
The TOPICS Program	55
Chapter 9	
CENTRAL BUSINESS DISTRICT PARKING AND CIRCULATION	57
Introduction	57
Study Area	57
Data Collection	57
Analysis	57
Results	59
CBD Circulation	60
Commercial Vehicles in the Central Business District	61
Transit Facilities in the Central Business District	61
Conclusions	61

Figures

		Page
1	1966 Study Area	4
2	1961 Study Area	5
3	Pre-Interview Letter	8
4	Trip Log Form	8
5	Interview Address Summary Form	9
6	Internal Trip Report Form	9
7	External Trip Report Form	11
8	Truck Report Form	11
9	Vehicle Ownership Trends in Yellowstone County	13
10	Vehicle Ownership as a Function of Family Income	13
11	1966 Screen Line Crossings	16
12	Friction Factor Comparisons Home Based Work Trips	24
13	Friction Factor Comparisons Home Based Other Trips	24
14	Friction Factor Comparisons Non Home Based Trips	24
15	Friction Factor Comparisons Commercial Vehicle Trips	25
16	Distribution of Exposition Drive Traffic	29
17	Typical Cross Sections	35
18	Zimmerman Trail Improvement Plan and Profile	38

Tables

		Page
1	Comparison of Adjusted 1961 Trip Data and Ground Traffic Counts at Screenlines	8
2	Summary of Trip Generating Characteristics	8
3	1966 Average Weekday Traffic Volumes at Cordon Stations	10
4	1966 Vehicles Crossing at Interview Stations by Type and Direction	10
5	Vehicle Ownership for Single Family Residences	14
6	Vehicle Ownership for Two Family Residences	14
7	Vehicle Ownership for Multi Family Residences	14
8	Purpose From-Purpose To for 1966 Average Weekday Internal Auto Driver Trips	15
9	Purpose From-Purpose To for 1966 Evening Peak Hour Internal Auto Driver Trips	15
10	Daily Traffic Variation	16
11	Monthly Traffic Variation	16
12	Planning District, Sub-District and Traffic Analysis Zone Correspondence	17
13	1966 Trips Between Planning Areas for All Purposes	17
14	1966 Total Trip End Generation by Sub-Districts	17
15	Comparison of 1966 and 1990 Population and Employment	21
16	Comparison of Trip Survey and Gravity Model Frequency Distribution	23
17	Origin Destination Survey vs. Gravity Model for Planning Area Traffic Movements	23
18	Origin Destination Survey vs. Gravity Model for Movements to CBD by Internal Sub-Districts	25
19	Trip Interchange Between Planning Areas 1990 Average Daily Trips	25
20	Highway User Operational and Time Costs	30
21	Twenty Year User Savings for Tested Networks	31
22	Estimated Cost of Recommended Improvements	54
23	1966 Central Business District Parking Inventory	58
24	Existing and Projected Employment for Central Business District	58
25	Parking Factors	59
26	1966 Parking Demand by Employment Categories	59
27	Theoretical 1990 Demand by Employment Categories	59
19	Zimmerman Trail Bridge Preliminary Design	38
20	Shiloh Road and Interstate 90 Interchange	39
21	Sixth St. W. and Central Ave. Channelization	40
22	N. 25th and N. 27th St., Grandview Dr. and Poly Dr. One-Way Couplet System	41
23	Division St. and N. 32nd St. One-Way Couplet System	42
24	Montana Route 3 N. 27th St. Interchange	43
25	Exposition Freeway Geometrics	44
26	Lockwood Connection Geometrics	45
27	Exposition Freeway 1990 Average Daily Traffic	46
28	Lockwood Connection 1990 Average Daily Traffic	46
29	Recommended Network	48
30	Areas of Widening Extensions and Channelization	49
31	1966 Average Daily Traffic	50
32	1990 Average Daily Traffic	51
33	Parking Study Area	58
34	Central Business District 1966 Average Daily Traffic	60
35	Central Business District 1990 Average Daily Traffic	60

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Summary of Recommendations

As a result of the technical studies presented in this report, and through a number of meetings with policy making groups in the Billings Area, a recommended system of streets and highways has been developed. This system was designed to provide adequate traffic circulation and overall capacity to the year 1990. The elements of this plan recommended for financing and construction during this period include the following major features:

Couplet Systems

Two systems of one-way couplets are planned to provide access to and through the Central Business District. These plans would utilize Montana-1st Avenue North for east-west flow and North 27th-North 25th Streets for north-south flow. This system would be compatible with any ultimate plan for all one-way streets in the core area. An additional one-way system is recommended for Division Street, North 33rd and North 32nd Streets to relieve traffic on some of the heavily-used intersections in this area.

1st Avenue South

Improvement to 1st Avenue South is recommended in order to relieve the heavy traffic demand on Montana Avenue between 6th Street West and Division Street. Inherent in this plan is improved channelization in the area of Central Avenue and 6th Street West to encourage east-west traffic to utilize 1st Avenue South.

17th Street West

An improved arterial is recommended in the north-south corridor utilizing sections of the existing 17th and 16th Streets West. This facility will provide a continuous north-south route between King Avenue and Rimrock Road which at present is unavailable. The possibility of linking this arterial to Montana Route 3 on top of the Rim was also investigated in detail. However, this plan was rejected due to engineering and aesthetic considerations.

Zimmerman Trail

To provide a bypass of the central area via a Rim connection, the possibility of an improvement of Zimmerman Trail was investigated. A plan and profile is presented in this report, including a structure to bridge the gully south of the Wilshire Park area, affording an improved alignment between Rimrock Road and Montana Route 3. This connection will relieve some of the traffic on Poly and Rimrock Roads, however, there will still be some widening of these facilities necessary to provide enough capacity in this corridor.

Shiloh Road Interchange

Additional access to Interstate 90 is recommended in the Shiloh Road area. As a near-term measure, this connection is shown as a simple diamond interchange. At some future date, when traffic volumes warrant a full north-south freeway in the vicinity of Shiloh Road, this connection should be converted to a freeway-to-freeway interchange compatible with the ideas presented in the Comprehensive Plan.

Exposition Drive

Due to the projected growth of the Heights Area, Exposition Drive will become the most heavily used facility in the highway network. To satisfy this forecasted traffic demand, two alternative solutions have been investigated. One alternate provides for a full access controlled facility parallel and to the west of the present arterial, extended to a connection with Interstate 90 south of the Stockyards. Another possibility is the construction of a link from the intersection of Secondary Route 318 and Route 87 to the Hardin Road Interchange with Interstate 90. The relative merits and geometric layout for each of these plans are presented in this report.

The forementioned elements constitute the major physical features of the plan. Additional recommendations are included in this study to cover such items as widening, channelization and downtown circulation and parking demand.

Figure 30 in this report presents a complete summary of areas of new construction, widening and channelization.

1

Chapter 1

Introduction

Transportation plays a vital role in the daily function of an urban area. Transportation influences land development patterns, affects the costs and times involved in shipments of raw materials and processed goods, and interacts in innumerable other ways in providing accessibility to job opportunities, residential housing choices, and social, educational and cultural opportunities.

On a typical weekday, residents of the Billings urbanized area complete in excess of 200,000 journeys, for work, personal business, shopping, social and receational purposes, and for a myriad of other reasons. These trips cover approximately 800,000 vehicle miles of travel and consume some 30,000 hours of driving time. This is a dramatic indication of how the quality of transportation service intimately affects the daily life pattern of Billings area citizens.

The demand for continuing improvement in transportation service is readily apparent. Since the end of World War II, vehicle registration in Yellowstone County has experienced a four-fold increase. Since the completion of the last transportation study in 1961, vehicle registration has increased by 20 per cent. As has been the case in other areas throughout the nation, vehicle ownership and total trip making has been growing at a faster rate than population. Two and three car families have long since ceased to be a novelty. In the Billings transportation study area about 43 per cent of the households are multi-car families, and the average ownership rate is over 1.2 vehicles per household. By the forecast year of 1990 the total vehicle registration for Yellowstone County is expected to be close to 85,000, compared with the current ownership of 40,000. Thus the demands on the transportation network are constantly increasing as development continues within the Billings area as well as in the remainder of Yellowstone County.

The transportation planning program recognizes the fundamental linkage between land use development and transportation. The program is predicated upon the development policies and concepts as embodied in the comprehensive planning studies that were in progress at the time of this study. Given these development guidelines, the transportation planning study seeks to interpret these plans in terms of travel demand, corridor flows, network and terminal facility requirements. The study will thus illustrate the transportation implications of any general plan and permit review and evaluation of planning policies as they relate to circulation and parking requirements. Finally, the transportation study program establishes a methodology to enable continued review and assessment of development proposals. In this way it provides an important tool for state, county, or city staff to evaluate policy actions.

Study Objectives

The purpose of this study is to develop an improved transportation system that would adequately meet the traffic demands of the Billings Metropolitan Area through the year 1990.

This system should satisfy three major requirements. First, it should be feasible in terms of engineering and financial considerations. Secondly, the plan should be fully coordinated and integrated with the goals of the Comprehensive Plan. Finally, the program of improvements must be acceptable to the general public.

Scope of Studies

The scope of work undertaken for this report contains all the elements usually incorporated in a comprehensive transportation plan. These elements can be summarized into a number of categories.

The first step is the compilation of basic data and the study of existing travel patterns. This would include such tasks as household interviews, roadside interviews, and the counting of existing traffic volumes on major streets and highways. The data is then processed and summarized for use in later work tasks.

The second stage of the transportation planning program is the development of an area wide travel model based on the data obtained in the previous step. This travel model is a system that can successfully simulate the travel demands of the base year, given the base year socio-economic parameters and transportation network.

After evaluating the ability of the model to successfully emulate existing travel demands, the future travel demands, in the form of an area to area trip table, is then developed. This table is evolved from the application of the travel model to future socio-economic parameters as determined in the Comprehensive Plan. This future trip demand table is, in effect, a natural result of the desired future land use for the Billings area.

Following these tasks, the next phase in the transportation planning program is to assign and accumulate the trip volumes on various network plans. The results of this traffic loading are evaluated with respect to such measures as overall traffic service, capacity standards, and economic considerations.

Finally, after testing a number of possible plans, the alternatives are narrowed down to a smaller set of workable choices based on traffic data. These alternatives are subjected to further detailed study such as cost estimates and geometric layouts in preparation for the final selection procedure by various technical and policy committees.

In addition to the transportation network studies, a parking study related to needs of the Central Business District was completed. This particular work element was not undertaken in great detail since the original 1961 Parking Study was very comprehensive in this area.[1] The scope of this phase was essentially limited to review of the previous study and an overall determination of parking needs in various CBD areas.

Figure 1
1966 Study Area

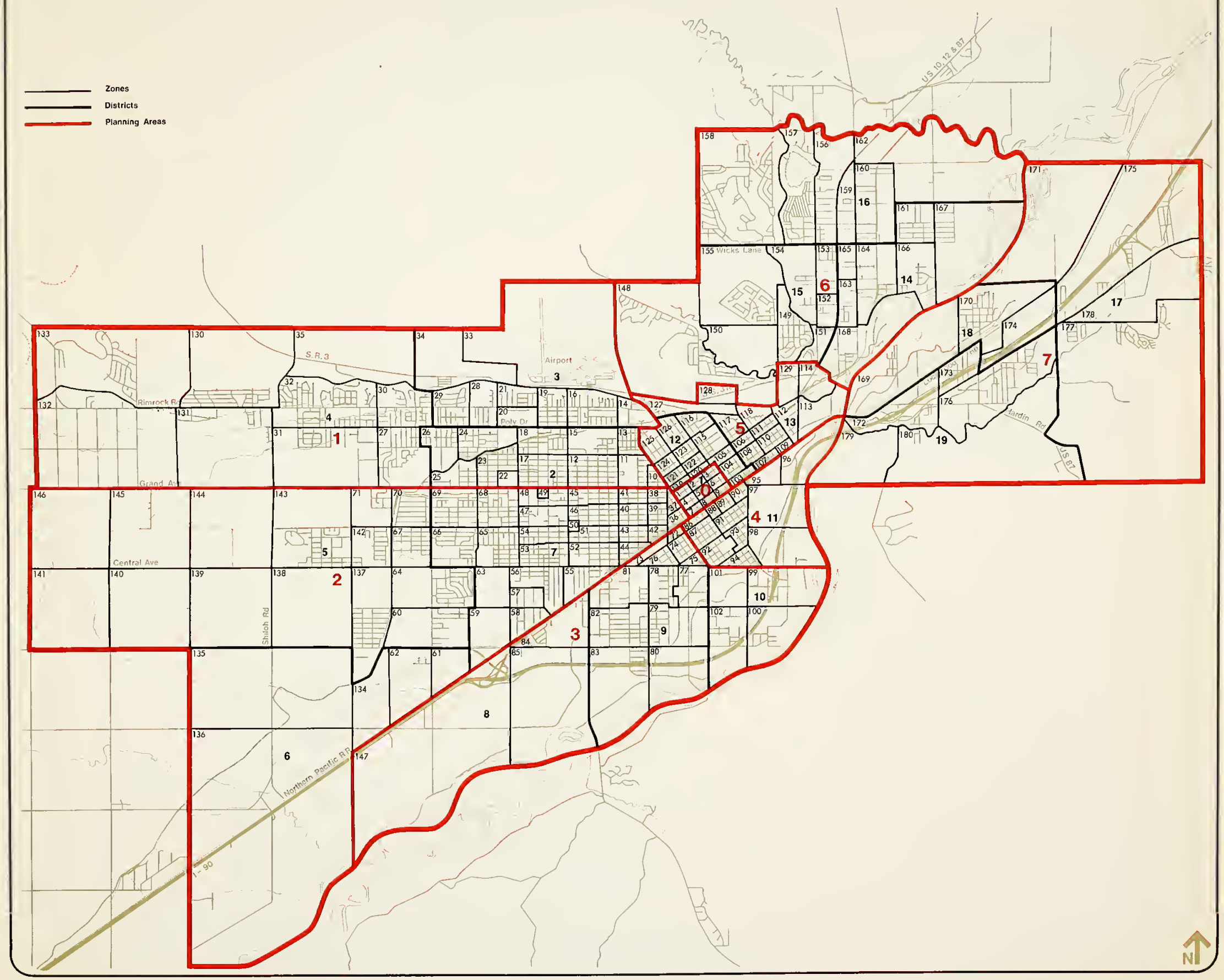


Figure 2
1961 Study Area

The Study Area

The first step in the transportation planning process is to define the geographical limits of the study area. The area included in this study as shown in Figure 1 encompassed the entire Billings Metropolitan Area as well as Lockwood and Billings Heights. The area is bounded on the north by a line parallel to Route 3, north of the airport. In the Heights area the northerly boundary was approximately a quarter of a mile north, and parallel to Five Mile Road. The easterly boundary was slightly over a mile to the east of Johnson Lane. The southerly boundary generally followed the Yellowstone River except in the Lockwood area where it was located in the vicinity of North Horseshoe Hills Road and Dry Creek Park. The westerly boundary was approximately along 64th Street West.

This study area contained a somewhat larger region than the 1961 Transportation Study.[2] At that time the Heights, Lockwood areas and all areas west of 40th Street were excluded. The 1961 area is shown in Figure 2.

For purposes of analysis, the internal study area is divided into major planning areas or districts, sub-districts, and zones.

The points of intersection between the study area boundary and major streets or highways are defined as external stations. The description of these stations is covered later in the text in the sections on data collection.

The Central Business District is defined as in former studies, that is, the area bounded by North 32nd and North 23rd Streets, between the Northern Pacific tracks (5th Avenue) and the Northern Pacific main line south of Montana Avenue.

Figure 1, in addition to showing the study area boundary, also depicts the analysis zone and station system.

1 Basic Data on Parking—DeLeuw Cather & Company
2 Billings Metropolitan Transportation Study—DeLeuw Cather & Company

2

Chapter 2

The Transportation Survey

The data that is collected at the beginning of the transportation planning process is the basic building block upon which all subsequent projections depend. The purpose of the transportation survey is not only to provide information on present patterns of travel, but also to provide a data base that can be analyzed to uncover the basic parameters influencing travel behavior.

The transportation survey can be classified into three major categories: the home interview, the roadside external survey and the commercial vehicle survey. The same general procedure was followed for each of these surveys. First a sample size is selected and the interviews are conducted. The collected sample data is then expanded to represent the entire study area; finally this expanded data is checked for accuracy.

Home Interview Survey

By far, the major proportion of all travel takes place completely within the study area confines. The characteristics of this travel can be accurately determined through a dwelling unit survey. Ideally, it would be desirable to interview every household in the survey area and to study travel habits over an extended period of time. However, this procedure would be extremely time consuming and expensive. Since travel habits of different individuals in a metropolitan area tend to be similar for similar trip purposes, it is not necessary to interview every household. In addition, travel for most individuals tends to be repetitive over time and occurs in a definite pattern. Therefore, it is not necessary to study the travel habits of an individual household over an extended period of time. Due to this similarity and repetition of travel patterns, it has been found that acceptable statistical sampling methods can be used with confidence. If a representative sample of households are interviewed over a brief time period, then this data can safely be taken as indicative of total travel occurring in the study area.

A statistical analysis of the Billings area resulted in a required interview size of 1,250 households. This size sample provides a 95 per cent probability that the total universe of trips was within a five per cent accuracy limit. In 1961 a total of 2,867 interviews were completed. Since the cost of a household survey remains high, every effort was made to fully utilize this available data. It was, therefore, decided to update this 1961 data by the use of a comparison between the 1961 and the 1966 screenline counts.

The initial adjustment attempted with the 1961 data was to apply an overall growth factor of 1.54. While this procedure produced a good overall comparison, it was found that the traffic during the peak periods was overestimated and the off-peak periods were underestimated. As a result, it was decided to adjust the data by trip purpose. The development of these factors by purpose involved an iterative process until a best fit to reproduce an hour by hour screenline crossing was found. The final factors were as follows:

Work Trips	1.04
Business Trips	2.31
Recreation Trips	1.36
Shopping Trips	1.80
Other Trips	2.04

Table 1 is a summary of these adjustments including a comparison of hourly trips with the 1966 ground counts.

In the expanded areas that were not included in the 1961 study a sample rate of one in five households was selected. Additional samples were completed in the 1961 survey area at a rate of 1 in 25. At these rates, a total of 1,373 samples were selected, 910 in the 1961 survey area and 463 in the expanded area.

These samples were selected from four basic information sources:

1. Utility Company billing ledgers.
2. The City Directory to determine the number of permanent dwelling units in the transient housing category.
3. On campus living quarters at Eastern Montana College.
4. On campus living quarters at Rocky Mountain College.

The home interview survey began on November 2, 1966 and was completed by December 13, 1966. With the two holidays in November eliminated, this time period spanned six Mondays, five Tuesdays, Wednesdays and Thursdays, and four Fridays.

For the most part, the interviews were conducted over the telephone. However, for about thirty per cent of the samples, personal contact was required. Personal interviews were conducted in some outlying areas where determination of the home zone was required. Personal contact was also deemed advisable for some households that generate a high numbr of trips, such as salesmen. In some cases, field checks had to be made because power company ledgers often record owner, not occupant of rental property.

Four field forms were utilized in the home interview survey. The first two forms, which were sent to selected households, were a pre-interview letter and a trip log. The forms used by the interviewers consist of the Interview Address Summary, which recorded the socio-economic characteristics of the household, and the Internal Trip Report. These various forms are shown in Figures 3, 4, 5 and 6.

Upon completion of this survey, the sample data was expanded to represent total internal trips. Factors were computed in accordance with the Bureau of Public Roads standard. This procedure is stated mathematically by the following equation:

$$F = \frac{A - (C \times \frac{A}{B})}{B - (C + D)}$$

where:

F = Dwelling unit expansion factor
A = Total number of addresses counted in the analysis zone
B = Total number of samples selected in the analysis zone
C = Total dwelling unit samples found vacant
D = Sum of sample interviews missed because of refusals, no one at home or contagious sickness

In addition to the dwelling unit expansion factor, a separate trip factor was computed and applied to all reported trips to account for the seasonal and daily travel variations in November and December. This factor was estimated to be 1.10.

The expansion of the home interviews revealed a total population of 77,463 residing in 22,915 dwelling units in the study area. In addition, there were 1,820 unoccupied dwelling units for a total of 24,735 units. A comparison of these figures with a land use study shows close agreement. In general the land use survey was slightly lower. This was due for the most part because of the differences in the definition of dwelling units. The land use survey did not include as dwelling units college dormitory units or permanent quarters in hotels and motels.

The trip generating characteristics found in the 1966 survey are in general agreement with the 1961 study. Table 2 is a summary of expanded study area data, with a comparison to the 1960 census data and the 1966 land use study. Additional data comparisons are shown with other Montana cities.

Table 1
Comparison of Adjusted 1961 Trip Data and Ground Traffic Counts at Screenlines

HOUR PERIOD BEGINNING	1961 EXPANSION BY PURPOSE					TOTAL	1966 GROUND COUNT
	Work X1.04	Business X2.31	Recreation X1.36	Shop X1.80	Other X2.04		
6 AM	672	37	83	—	533	1,325	1,506
7 AM	3,765	277	105	73	2,238	6,458	6,111
8 AM	2,715	523	314	171	2,178	5,901	6,142
9 AM	1,013	1,130	665	600	1,005	4,413	4,990
10 AM	844	1,189	686	1,485	767	4,971	4,972
11 AM	601	1,064	644	1,170	1,768	5,247	6,078
12 PM	1,573	1,106	369	919	4,487	8,454	7,814
1 PM	1,930	1,388	720	1,164	1,839	7,041	6,828
2 PM	1,000	1,228	895	1,183	1,115	5,421	6,493
3 PM	1,241	1,008	808	1,867	2,179	7,103	7,679
4 PM	2,154	836	939	2,014	2,857	8,800	9,666
5 PM	3,682	988	1,015	1,957	3,115	10,757	9,440
6 PM	1,320	710	1,184	1,137	1,917	6,268	6,328
7 PM	673	704	2,976	1,614	1,480	7,447	6,061
8 PM	579	620	2,240	1,128	1,066	5,633	4,773
9 PM	439	449	1,663	311	789	3,651	3,972
	24,201	13,257	15,306	16,793	29,333	98,890	98,853

Table 2
Summary of Trip Generating Characteristics

	1960 CENSUS	1961 TRANSPORTATION STUDY	1966 TRANSPORTATION STUDY	1966 LAND USE STUDY	1965 MISSOULA TRANSPORTATION STUDY	1961 GREAT FALLS TRANSPORTATION STUDY
Population	60,712	58,718	77,463	73,652	46,430	74,735
Dwelling Units	18,842	17,568	24,735	23,345	14,610	23,815
Vehicles	—	22,734	30,889	—	25,767	27,057
Total Trips	—	144,788	210,180	—	157,274	162,851
Persons per Dwelling Unit	3.19	3.34	3.13	3.15	3.18	3.14
Persons per Vehicle	—	2.58	2.51	—	1.80	2.76
Vehicles per Dwelling Unit	—	1.29	1.25	—	1.76	1.14
Trips per Person	—	2.47	2.58	—	3.39	2.18
Trips per Dwelling Unit	—	8.24	8.51	—	10.76	6.84

Figure 3
Pre-Interview Letter

BILLINGS – YELLOWSTONE
CITY-COUNTY PLANNING BOARD
ROOM 303 - COURTHOUSE PHONE 252-5181
BILLINGS, MONTANA

Dear Citizen:

The Billings-Yellowstone City-County Planning Board is in the process of preparing a comprehensive plan to guide the development of the Billings urbanized area. Current factual information on travel is needed to prepare a plan reflecting the desires and interests of the citizens. Your household is one of a small number selected for the purpose of obtaining current information on travel. What this will mean to you, as citizen, is a better community served by improved highways, streets, roads and transit service.

Sometime in person during the day of Tue Dec 6 an interviewer will contact you ~~by telephone~~. After identifying herself she will ask you questions pertaining to travel by all members of your family, ages five years or older, during the 24-hour period beginning at 4:00 A.M. Mon Dec 5 and ending at 4:00 A.M. Tue Dec 6. Enclosed is a set of travel logs. It would be helpful to both you and the interviewer if prior to the interview, you have recorded in the log all travel for the indicated 24-hour period. The log should be self-explanatory.

If no one at your residence will be at home when the interviewer is scheduled to call, please call 252-5181, extension 285 and inform them of this fact.

Very truly yours,

Howard E. Hultgren
Howard E. Hultgren, President
City-County Planning Board

Willard E. Fraser
Willard E. Fraser
Mayor of Billings

M. E. McClintock
M. E. McClintock
Chairman of County Commissioners

Participating Agencies: City-County Planning Board, Montana Highway Commission, U. S. Department of Commerce - Bureau of Public Roads, U. S. Department of Housing and Urban Development.

Figure 4
Trip Log Form

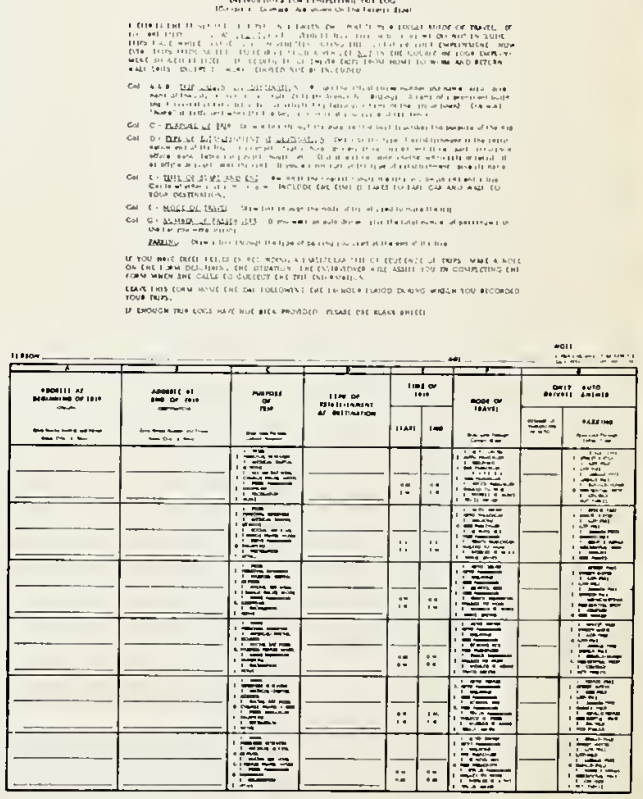


Figure 5
Interview Address Summary Form

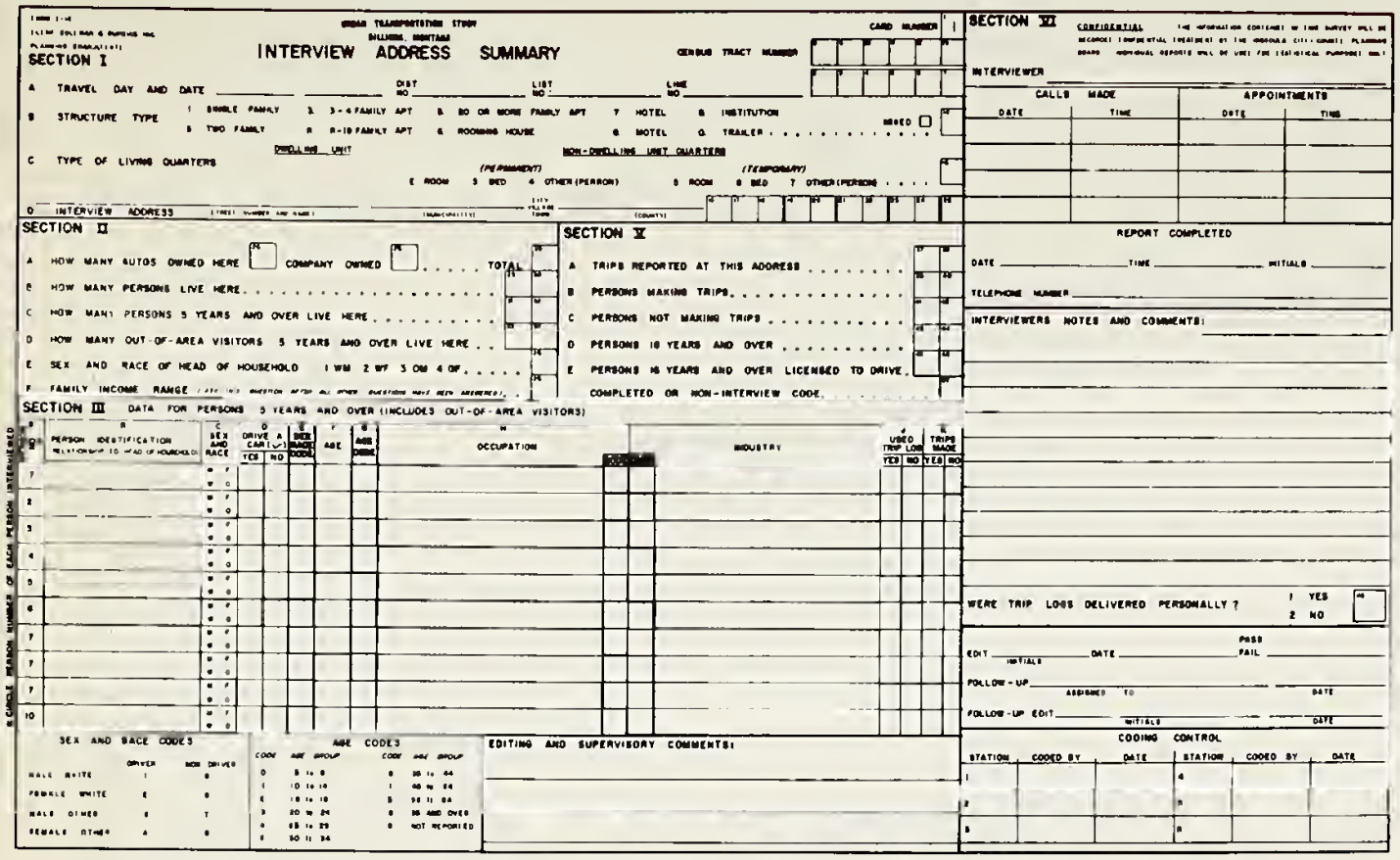
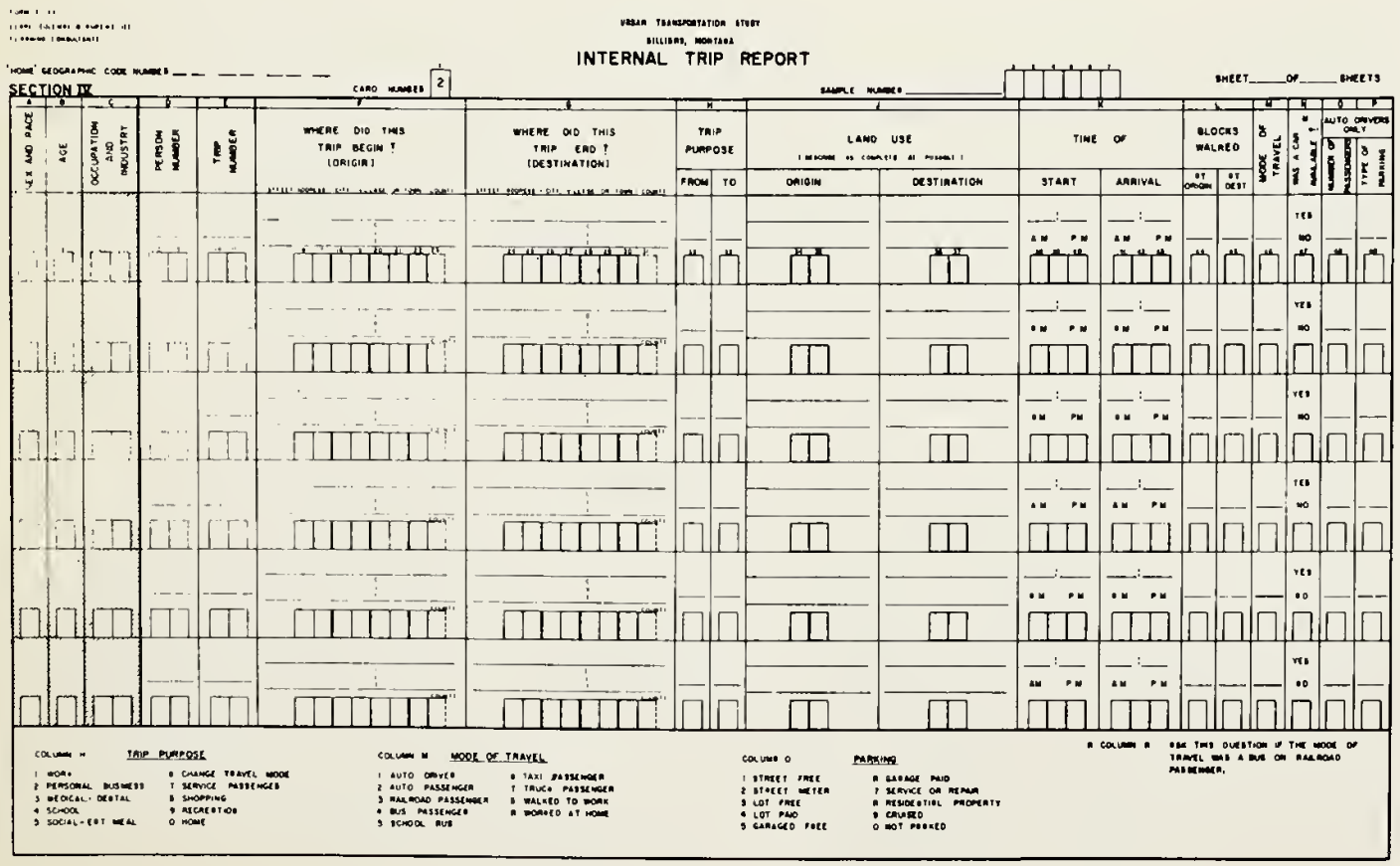


Figure 6
Internal Trip Report Form



Roadside Survey and External Travel

The home interview survey could partially supply external travel data. However, this survey would obviously miss all trips into or out of the area that are made by non-residents. It would also miss trips that passed entirely through the area. As previously mentioned, the major proportion of all trips is within the study area limits; however, passenger and commercial vehicle travel entering, leaving and passing through the Billings urban area is substantial enough to warrant a detailed study.

The Billings transportation study area, encompassed by a boundary or the cordon line, is illustrated in Figure 1. This cordon line crossed 21 possible entry points to the area. Of these 21 locations, it was found that ten crossings accounted for about 96 per cent of the total vehicles entering or leaving the area. These ten crossing points were selected as interview stations.

Traffic volume counts were made on all cordon crossing points and additional manual classification counts were made at the ten interview stations between 6:00 A.M. and 10:00 P.M. The total volume count at the cordon line was 16,957. Table 3 shows the total traffic crossings at nineteen locations. Table 4 is a summary for all the stations of the hourly distribution of crossings by vehicle type and direction. The traffic volume counts were carried out between April and October 1966. To provide a common basis of comparison, these counts were adjusted for seasonal and monthly variations.

The roadside interview at the ten selected locations was carried out in August and September of 1966. A hundred per cent sample of all outbound traffic was attempted at all times. The

interviews were conducted between the hours of 6:00 A.M. and 10:00 P.M. Approximately 90 per cent of the total cordon crossings occurred during this time period. Figure 7 is a sample of the external interview form utilized in this survey.

Out of a total traffic stream of 8,843[1] during the interview period, a total of 8,450 interviews were completed. Of these 8,450 interviews, 147 were rejected for various reasons. Therefore, the completed interviews actually used amounted to about 94 per cent of the outbound traffic stream during the hours of interview.

Following the collection of field data, a set of expansion factors were developed for passenger and commercial vehicles. These factors were computed for each hour of the interview period and have been adjusted for seasonal and daily variation. For commercial vehicles, additional adjustments were made to account for multiple axles in the mechanical counts at all interview stations. The formula used to develop the expansion factors can be stated as follows:

$$H = \frac{O}{P} \times \frac{V}{W} \times \frac{S}{T}$$

where:

- H = Hourly expansion factor
- O = Number of vehicles (passenger or commercial) counted during the hour of the interview
- P = Number of completed interviews for each group of vehicles during the hour
- V = Average mechanical count of all vehicles during the applicable hour
- W = Actual number of vehicles counted during hour of interview
- S = Average mechanical count, corrected for seasonal and daily variations, of all traffic passing the station during the 24 hour period
- T = Average mechanical count of all vehicles passing the station during the hours that interviews were made.

The application of the expansion factors to the trip data yielded a total of 17,108 crossings, of which 2,331 were through trips that did not stop in the area. These 17,108 cordon crossings compare well with the Average Weekday Daily total of 16,957; the small discrepancy was due to rounding of the factors.

Finally, the inbound travel was accounted for by assuming this travel was a mirror image of the outbound characteristics. Essentially, the outbound data was reproduced with origin and destinations, and trip purposes reversed.

1 This figure is unadjusted for monthly variation, therefore it does not agree with Table 4.

Table 3
1966 Average Weekday Traffic Volumes at Cordon Stations (Both Directions)

STATION NUMBER		1966 A.W.D. TRAFFIC VOLUME
1 & 2	U.S. 10 and 87 on Billings Bench	4,614
3	Bitterroot Dr., ½ mi. north of Mary St.	77
4	Old Hardin Road, east of Johnson Lane	175
5	Unnamed Road, ½ mi. east of old Hardin Road	144
6	U.S. 212, 1 mi. southeast of Johnson Lane	1,804
7	Coburn Rd., 1 mi. south of U.S. 87	202
8	Billings Blvd. at Yellowstone River Bridge	972
10	South frontage road, 1 mi. southwest of Shilo Rd. Overpass	1,349
11	County Road, 1 mi. west of Shilo, I 90 overpass	59
12	Hesper Rd., west of 48th St. W.	30
13	Kings Ave., west of 48th St. W.	699
14	Central Ave., west of 48th St. W.	201
15 & 16	Grand Ave. corridor, west of 48th St. W.	263
17	County Road, west of jct. with FAS 302	28
18	FAS 302, ½ mi. southeast of N.P. underpass	531
19	Montana 3, 1½ miles northwest of Zimmerman Trail	940
21	Interstate 90 on west Cordon Line	4,869
	Total	16,957

Note: No cordon crossings at Stations 9 and 20.

Table 4
1966 Vehicle Crossings at Interview Stations by Type and Direction (Adjusted for Seasonal Variations)

HOUR BEGINNING	INBOUND		OUTBOUND		TOTAL VEHICLES
	Passenger Vehicles	Commercial Vehicles	Passenger Vehicles	Commercial Vehicles	
6 AM	96	58	170	104	428
7 AM	292	158	271	128	849
8 AM	339	139	322	170	970
9 AM	370	140	328	140	978
10 AM	382	173	336	174	1,055
11 AM	404	176	337	138	1,055
Noon	353	125	340	120	938
1 PM	397	148	352	151	1,048
2 PM	368	185	375	161	1,089
3 PM	433	221	425	186	1,265
4 PM	454	235	494	197	1,390
5 PM	461	151	492	191	1,295
6 PM	403	138	360	122	1,023
7 PM	387	117	248	90	842
8 PM	246	78	230	55	609
9 PM	188	65	203	49	505
Totals	5,583	2,307	5,283	2,176	15,349

Truck and Taxi Survey

The data for internal truck travel was developed entirely from the updating of the 1961 interviews. A sample of the 1961 truck report is shown in Figure 8. This updating consisted of the review of sample selection, interviewing techniques and the development of expansion factors.

In 1961 it was estimated that there were 4,590 trucks registered in the study area. Of this number, 1,530 or one-third were selected for interviews, and 1,113 interviews were successfully completed. At that time an original expansion factor of 4.0 was developed. However, after comparing some screenline ground counts with the expanded trip data it was concluded that the factor was low. A final 1961 expansion factor of 5.6 was used to yield a more complete screenline comparison.

From 1961 to 1966 the number of trucks registered in Yellowstone County increased from 9,469 to 11,507 or 21 per cent. The truck registration in the State of Montana increased from 116,111 to 141,916, or 22.2 per cent in the same five year period.

A growth factor from 1961 to 1966 was developed by the comparison of total counts across two screenlines for each of the two years. These screenlines were an east-west line along the Northern Pacific Railroad tracks, and a north-south line dividing the urbanized area into an east and west portion. It was found that an expansion factor of 1.66 to the 1961 total truck trips would yield an adequate comparison with the 1966 truck screenline volumes. Therefore, a total factor of 9.3 was applied to the original 1961 sample to represent the full universe of truck travel for 1966.

The 1961 commercial vehicle survey recorded the trips for all taxis registered in the study area. A 100 per cent sampling of the 20 taxis owned by the Yellow Cab Company and the Eagle Cab Company produced a total of 1,868 trips. Of this total, 1,814 trips were entirely within the survey area limits.

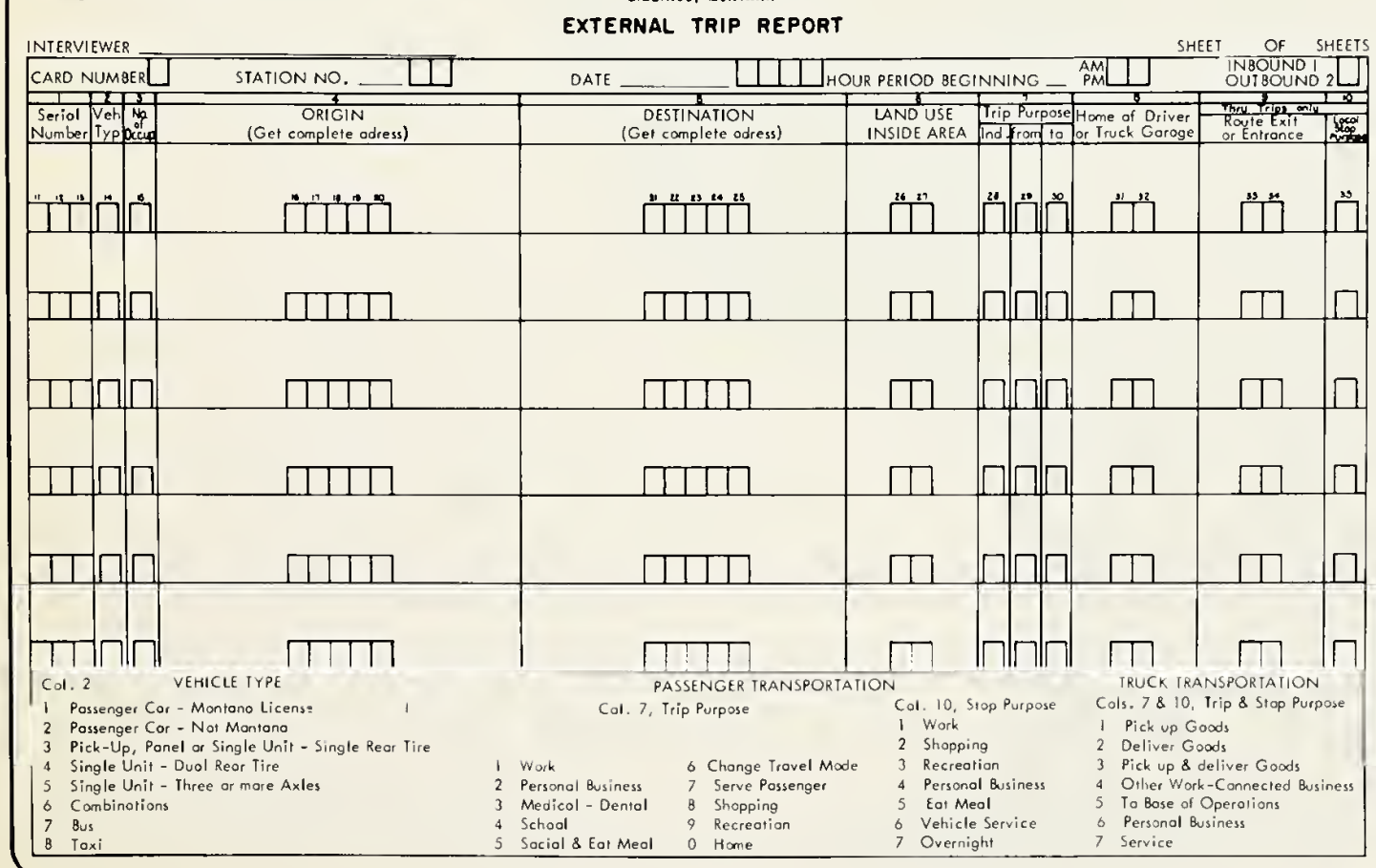
The ground counts in 1961 indicated 359 taxi crossings of screenline along the Northern Pacific Railroad tracks. In 1966, the taxi crossings of the same screenline amounted to 419 trips, a growth of 16.7 per cent. Therefore, to represent the total 1966 taxi trips, an expansion factor of 1.2 was applied to the 1961 taxi survey.

The results of the above-described factoring process yielded the following totals for 1966 truck and taxi travel.

Internal TruckTrips	37,608
Internal Taxi Trips	2,185
External Truck Trips	1,837
(From the External Survey)	
External Taxi Trips	(nominal)
Total	41,630

This completed the data collection phase of the study. All the trip data and household characteristics were then transferred to punch cards or computer tape for subsequent processing in other elements of this study.

Figure 7
External Trip Report Form


URBAN TRANSPORTATION STUDY
BILLINGS, MONTANA
EXTERNAL TRIP REPORT

INTERVIEWER ____ SHEET ___ OF ___ SHEETS

CARD NUMBER ☐ STATION NO. ____ ☐☐ DATE ____ ☐☐☐☐ HOUR PERIOD BEGINNING ____ AM PM ☐☐ INBOUND 1 OUTBOUND 2 ☐

1 Serial Number	2 Veh Type	3 No. of Occup	4 ORIGIN (Get complete adress)	5 DESTINATION (Get complete adress)	6 LAND USE INSIDE AREA	7 Trip Purpose Ind	From	to	8 Home of Driver or Truck Garage	9 Thru Trips only Route Exit or Entrance	10 Local Stop Purpose
11 12 13	14	15	16 17 18 19 20	21 22 23 24 25	26 27	28	29	30	31 32	33 34	35

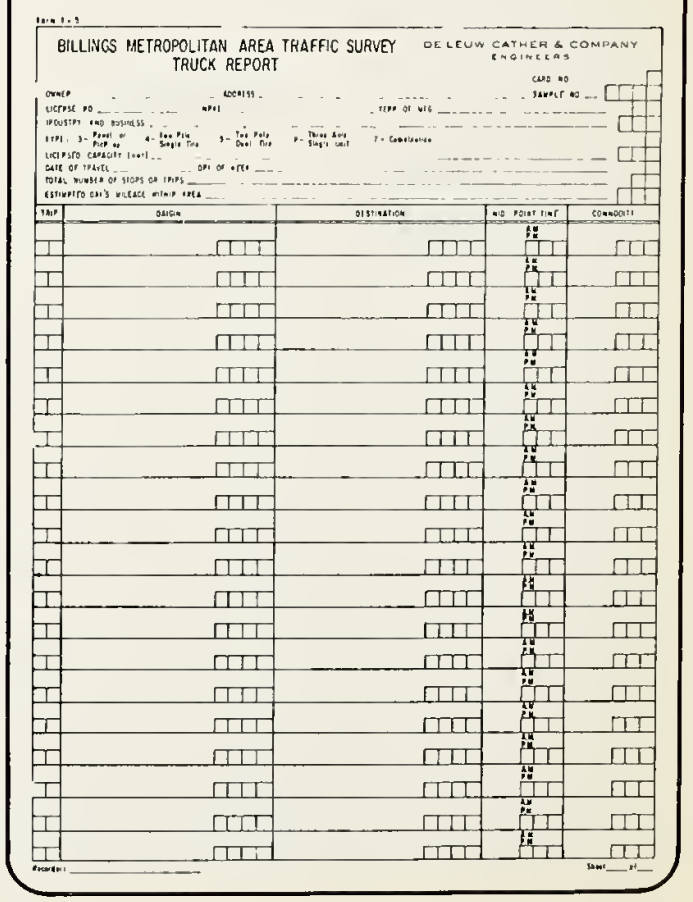
Col. 2 VEHICLE TYPE
1 Passenger Car - Montana License
2 Passenger Car - Not Montana
3 Pick-Up, Panel or Single Unit - Single Rear Tire
4 Single Unit - Dual Rear Tire
5 Single Unit - Three or more Axles
6 Combinations
7 Bus
8 Taxi

PASSENGER TRANSPORTATION
Col. 7, Trip Purpose
1 Work
2 Personal Business
3 Medical - Dental
4 School
5 Social & Eat Meal
6 Change Travel Mode
7 Serve Passenger
8 Shopping
9 Recreation
0 Home

Col. 10, Stop Purpose
1 Work
2 Shopping
3 Recreation
4 Personal Business
5 Eat Meal
6 Vehicle Service
7 Overnight

TRUCK TRANSPORTATION
Cols. 7 & 10, Trip & Stop Purpose
1 Pick up Goods
2 Deliver Goods
3 Pick up & deliver Goods
4 Other Work-Connected Business
5 To Base of Operations
6 Personal Business
7 Service

Figure 8
Truck Report Form


BILLINGS METROPOLITAN AREA TRAFFIC SURVEY
TRUCK REPORT
DE LEUW CATHER & COMPANY
ENGINEERS

CARD NO
SAMPLE NO

OWNER ____ ADDRESS ____
LICENSE NO ____ MPG ____ TEMP OF WTG ____
INDUSTRY AND BUSINESS ____
TYPE: 3 - Panel or Pick up 4 - Two Axle Single Tire 5 - Two Axle Dual Tire 6 - Three Axle Sing'n unit 7 - Combination
LICENSED CAPACITY (cwt) ____
DATE OF TRAVEL ____ DAY OF WEEK ____
TOTAL NUMBER OF STOPS OR TRIPS ____
ESTIMATED GM'S MILEAGE WITHIN AREA ____

TRIP	ORIGIN	DESTINATION	MID POINT TIME	COMMODITY
			AM PM	
			AM PM	
			AM PM	

3

Existing Travel Characteristics

Transportation planning for future demands require a thorough understanding of existing travel characteristics. The surveys that were described in the previous chapter provide important data regarding present patterns of the Billings urban area. Although it cannot be assumed that the present patterns of travel will remain unchanged, it is reasonable to expect that certain socio-economic conditions that motivate travel desires will prevail in the future. Data on vehicle ownership, trip purposes, traffic characteristics and travel patterns are described in this chapter of the report.

Figure 9
Vehicle Ownership Trends in Yellowstone County

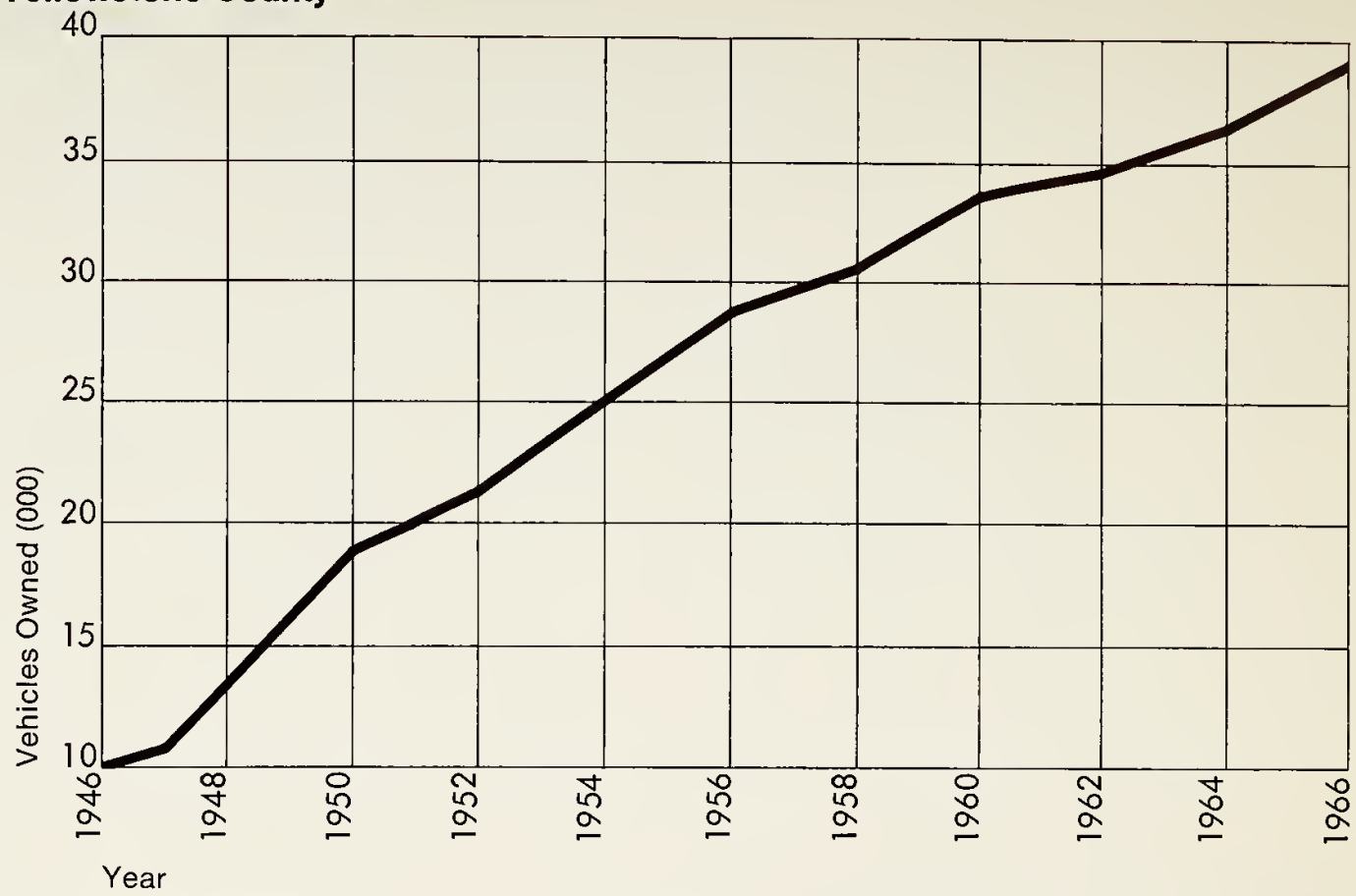


Figure 10
Vehicle Ownership as a Function of Family Income

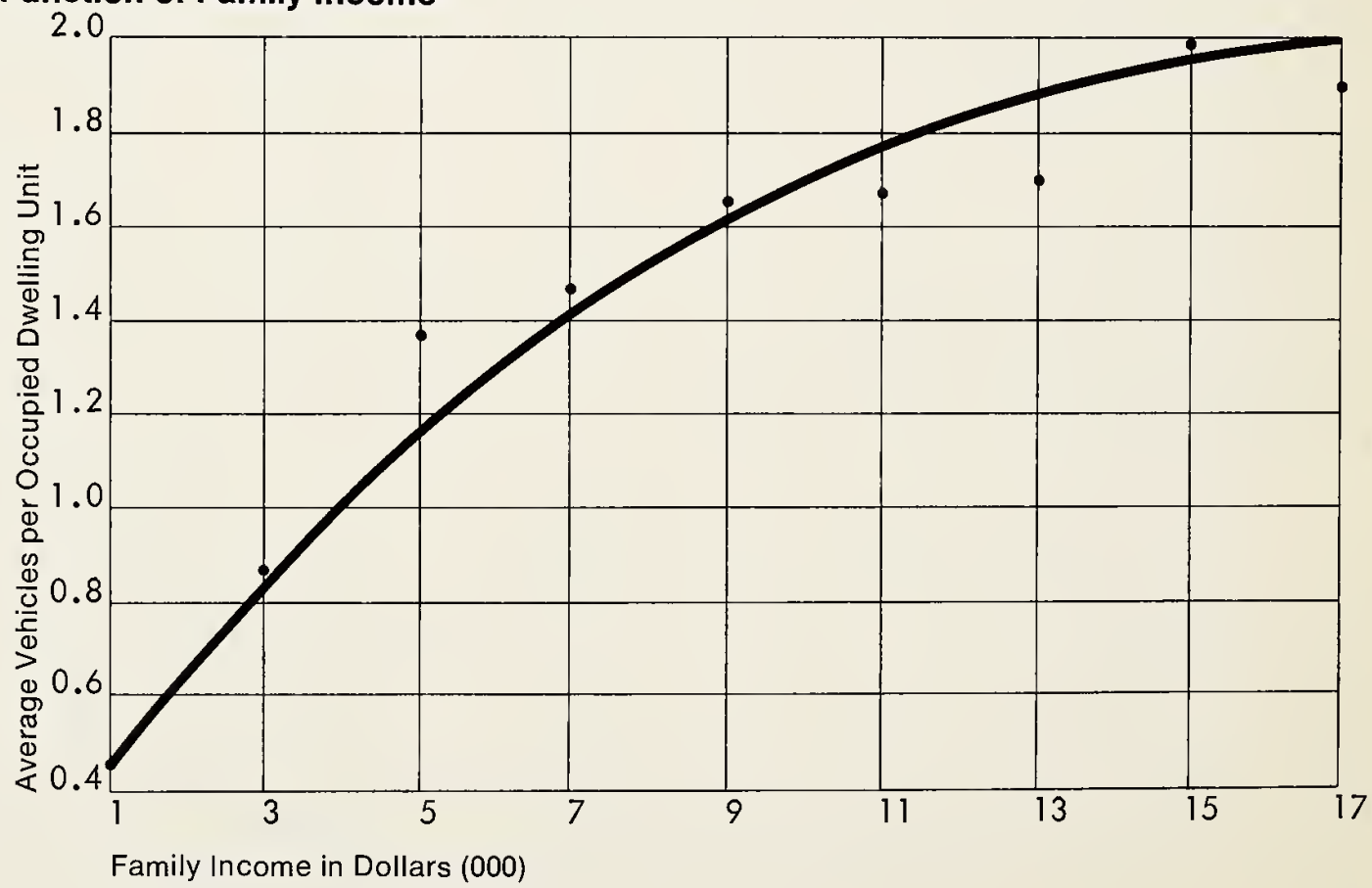


Table 5
Vehicle Ownership for Single Family Residences

Number of Residents Over 5 Years Old	NUMBER OF VEHICLES OWNED 0	1	2	3	3+	TOTAL DWELLING UNITS	TOTAL VEHICLES	AVERAGE VEHICLES PER DWELLING UNIT
1	1226	1103	107	5	0	2,441	1,332	0.55
2	778	2944	2849	198	60	6,829	9,476	1.38
3	182	1293	1457	263	107	3,302	5,424	1.63
4	46	923	1902	346	53	3,270	5,977	1.82
5	0	1082	1578	345	92	3,097	5,641	1.82
					Total	18,939	27,850	1.47

Table 6
Vehicle Ownership for Two Family Residences

Number of Residents Over 5 Years Old	NUMBER OF VEHICLES OWNED 0	1	2	3	TOTAL DWELLING UNITS	TOTAL VEHICLES	AVERAGE VEHICLES PER DWELLING UNIT
1	282	146	0	0	428	146	0.34
2	91	750	147	27	1,015	1,125	1.11
3	0	264	98	28	390	544	1.39
4	0	51	24	0	75	99	1.32
5	0	48	24	0	72	96	1.33
				Total	1,980	2,010	1.01

Table 7
Vehicle Ownership for Multi-Family* Residents

Number of Residents Over 5 Years Old	NUMBER OF VEHICLES OWNED 0	1	2	3	TOTAL DWELLING UNITS	TOTAL VEHICLES	AVERAGE VEHICLES PER DWELLING UNIT
1	1023	360	24	0	1,470	408	0.29
2	53	249	107	0	409	463	1.13
3	46	83	24	0	153	131	0.86
4	0	27	0	0	27	27	1.00
5	0	0	0	0	0	0	—
				Total	1,996	1,029	0.52

*More than two families per dwelling unit

Vehicle Ownership

The most significant single factor that is associated with the production of trips is the availability of an automobile. Since 1946 the total vehicle ownership of Yellowstone County has shown a steady increase. This yearly increase is shown graphically in Figure 9.

There are a number of factors that influence automobile ownership. Most notable of these are income, dwelling unit density, family size and the availability of public transportation. In other studies it has usually been found that as distance from the Central Business District increases, average car ownership increases. This is due to the reduction in density at greater distances from the CBD. The effect of density on vehicle ownership for the Billings area is illustrated in Tables 5, 6 and 7. The average vehicle ownership for single family dwellings is 1.47 while the average for multiple dwelling units is 0.52 vehicles per dwelling unit. These tables also illustrate the effect of family size on the level of ownership.

As was expected, family income has a marked effect on vehicle ownership. Figure 10 illustrates the effect of income on the average of autos per dwelling unit. This hand fitted curve shows that income has a greater effect at the lower income ranges. Between the range of $3,000 to $5,000 the average ownership increased 35 per cent. However, a $2,000 increase in family income from the $7,000 to $9,000 range caused only about a 10 per cent increase in car ownership.

The availability of good public transit facilities has shown, in other areas, a tendency to keep vehicle ownership at a lower level. However, the Billings area does not possess a transit system of a magnitude to affect auto ownership.

Trip Purpose and Peaking Characteristics

In this study ten trip purposes were recorded. The purposes were recorded for each end of the trip as was the procedure in previous studies. This, then, afforded complete compatibility between the new data and the 1961 data. The trip

purposes recorded in the home interview were home, work, business, medical-dental, school, social-recreation, change travel mode, eat meal, shopping and serve passenger. Table 8 illustrates the basic relationship between these specific and general trip purposes. This table is the sum of all internal auto driver trips from the updated 1961 data and the new data for 1966. Not included in this table are external and commercial vehicle trips. The total trips of 155,550 is about 13 per cent higher than similar data from the 1961 home interviews. As indicated by this table, slightly more than two-thirds of all internal trips either originate or terminate in the home. The largest number of trips for a single purpose was between home and work with shopping and recreational trips a close second and third.

In addition to the internal trips reported, there were 14,837 auto driver and commercial internal-external and through trips, and another 39,793 internal commercial vehicle trips. Total area trips are summarized as follows:

Summary of 1966 Trips by General Purpose

	INTERNAL	EXTERNAL & THROUGH
Home Based Work	22,984	3,123
Home Based Other	84,775	8,071
Non-Home Based	47,791	1,806
Sub-Total	155,550	13,000
Commercial Vehicles	39,793	1,837
TOTAL	195,343	14,837
Total All Trips	210,180	

The planning of a future transportation network is often predicated on the peak hour demand. It is therefore useful to study the travel patterns for some peak hour. From available existing ground counts in the Billings area, it was determined that the hour of peak demand occurs between 4:30 and 5:30 P.M. From the home interview data, Table 9 was developed which shows the relationship between trip purposes during this evening peak period. The total internal auto driver trips that depart from their origins during this hour is 19,234, or 12.4 per cent of the daily total. As expected, the single largest peak movement involved trips associated with work. There were 4,031 trips between work and home during this hour. This amount represents 36 per cent of the total daily trips from work to home.

A summary of this peak hour purpose table indicates that the directional split during this period would be about two to one. That is, the traffic in the heavier outbound direction should be approximately twice the flow of the inbound direction. The actual directional split observed on any specific facility could vary greatly from this, depending on the type of street and local land use in the area. However, a pattern close to a two to one split should prevail on major arterials, especially those facilities with a Central Business District orientation.

Table 8
Purpose From - Purpose To for 1966 Average Weekday Internal Auto Driver Trips

		PURPOSE TO										
		Home	Work	Personal Business	Medical Dental	School	Social & Eat Meal	Change Mode	Serve Passenger	Shopping	Recreation	Total
PURPOSE FROM	Home	0	11,799	6,245	778	1,266	8,887	61	2,337	11,190	11,539	54,102
	Work	11,185	6,526	1,041	74	60	670	26	5,223	948	1,579	27,332
	Personal Business	5,417	806	1,528	57	29	572	6	241	1,297	457	10,410
	Medical Dental	634	24	72	68	6	55	0	40	242	89	1,230
	School	1,048	101	25	17	10	167	0	233	83	117	1,801
	Social & Eat Meal	9,790	486	419	39	54	2,002	0	368	1,080	1,075	15,313
	Change Mode	46	6	0	0	0	0	0	11	6	0	69
	Serve Passenger	2,221	3,390	249	44	204	408	11	468	359	553	7,907
	Shopping	13,013	257	708	29	16	1,223	0	402	3,275	747	19,670
	Recreation	10,303	1,261	500	89	230	996	10	449	1,277	2,601	17,716
	Total	53,657	24,656	10,787	1,195	1,875	14,980	114	9,772	19,757	18,757	155,550

Table 9
Purpose From - Purpose To for 1966 Evening Peak Hour Internal Auto Driver Trips

		PURPOSE TO										
		Home	Work	Personal Business	Medical Dental	School	Social & Eat Meal	Change Mode	Serve Passenger	Shopping	Recreation	Total
PURPOSE FROM	Home	0	369	448	20	17	620	10	295	1,163	1,139	4,081
	Work	4,031	616	180	10	0	96	0	297	413	530	6,173
	Personal Business	771	24	62	0	0	69	0	15	94	107	1,142
	Medical Dental	138	0	29	0	0	0	0	0	39	10	216
	School	109	0	0	0	0	19	0	6	21	10	165
	Social & Eat Meal	680	12	30	10	0	190	0	11	177	107	1,217
	Change Mode	25	0	0	0	0	0	0	6	0	0	31
	Serve Passenger	230	24	28	0	0	12	0	69	12	29	404
	Shopping	2,135	24	117	0	6	88	0	62	669	157	3,258
	Recreation	1,780	37	48	0	0	77	0	21	233	351	2,547
	Total	9,899	1,106	942	40	23	1,171	10	782	2,821	2,440	19,234

Traffic Characteristics

Traffic flow on the streets and highways of the study area exhibits a continual changing demand. This varying demand occurs during the hours of the day, the days of the week and the months of the year. The hourly variation in flow is illustrated in Figure 11. This illustration portrays the volume of trips crossing a cordon line around the west and south side of the Central Business District. In addition to the evening peak period, there are two secondary peaks shown on this exhibit, at 7 A.M. and noon. The midday peaking condition is probably due to a number of people returning home for lunch, or other personal business, and shopping purposes conducted during the noon hour.

Tables 10 and 11 show the daily and monthly variation of traffic flow. These data are listed for three types of facilities and are expressed as a per cent of the daily or monthly averages. As is evident from these tables the variation of interstate and rural highways are similar; however, the variations on city streets exhibits quite different characteristics. This is no doubt due to the higher percentage of seasonal recreational travel carried on the interstate and rural highways. This recreational travel also shows its effect on Sunday travel, which is substantially higher for these two types of facilities.

Table 10
Daily Traffic Variation
(Expressed as a percent of the average)

	INTERSTATE		RURAL HIGHWAYS		CITY STREETS	
	Average Weekday	Average Daily	Average Weekday	Average Daily	Average Weekday	Average Daily
Monday	102.0	99.1	100.4	95.4	100.1	101.8
Tuesday	96.4	93.6	95.5	90.8	96.0	97.5
Wednesday	95.0	92.1	97.0	92.3	95.6	97.2
Thursday	97.2	94.4	97.1	92.4	97.0	98.5
Friday	109.4	106.2	110.0	104.5	111.3	113.0
Saturday	—	103.7	—	108.4	—	116.7
Sunday	—	110.9	—	116.2	—	75.2

Figure 11
1966 Screen Line Crossings

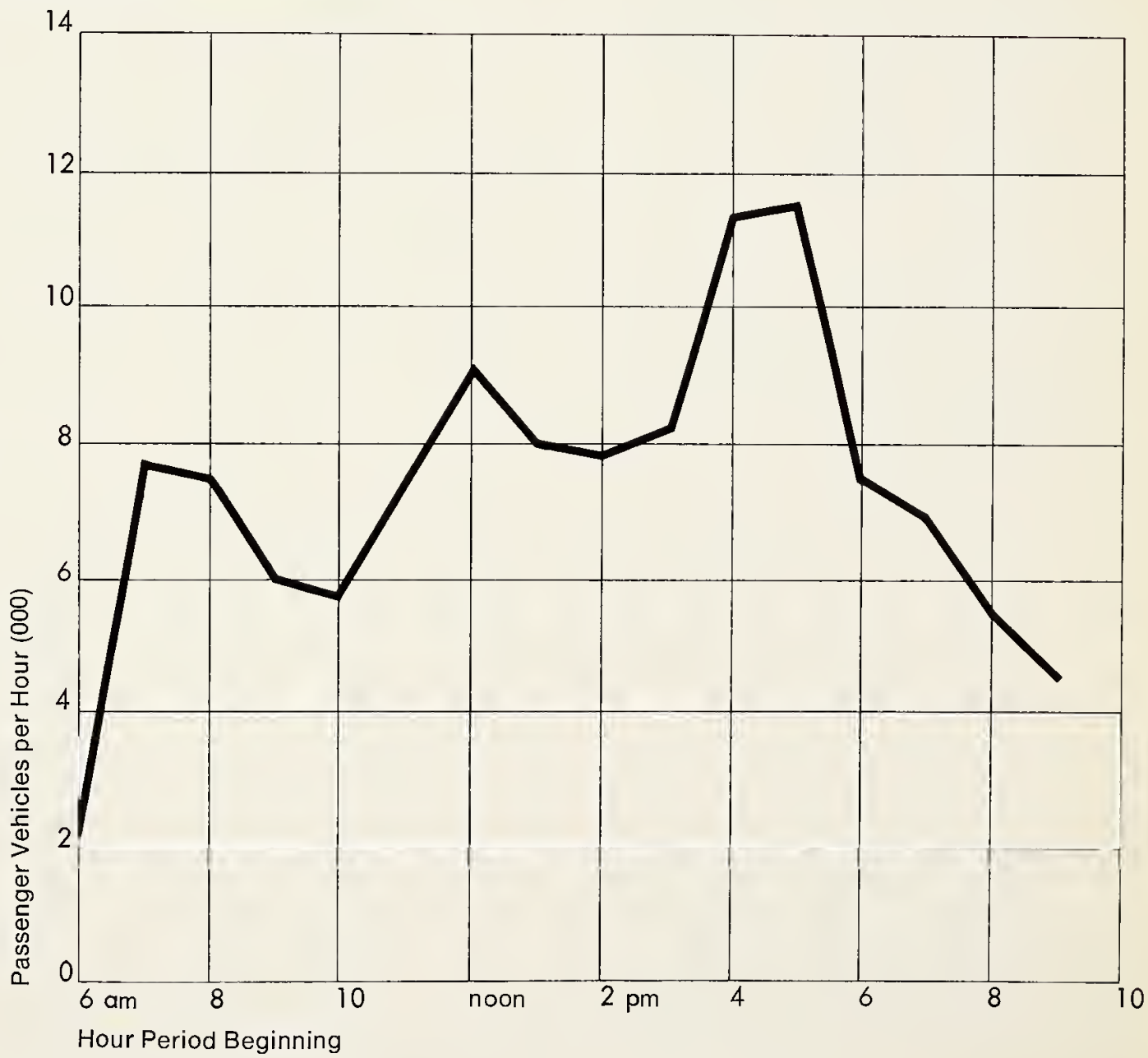


Table 11
Monthly Traffic Variations
(Expressed as a percent of annual average monthly traffic)

	INTERSTATE HIGHWAYS	RURAL HIGHWAYS	CITY STREETS
January	74	77	90
February	80	84	96
March	85	91	99
April	93	99	104
May	101	105	113
June	119	110	109
July	126	114	104
August	127	115	98
September	110	110	99
October	100	105	97
November	95	99	91
December	89	93	101

Table 12
Planning District, Sub-District and Traffic Analysis Zone Correspondence

PLANNING DISTRICT	SUB-DISTRICT	TRAFFIC ANALYSIS ZONES
0	1	1 through 9
1	2	10 through 13, 15, 17, 18, 22 through 26
1	3	14, 16, 19, 20, 21, 28, 29, 33, 34
1	4	27, 30, 31, 32, 35, 130 through 133
2	5	60, 64, 67, 70, 71, 137 through 146
2	6	61, 62, 134 through 136
2	7	36 through 59, 63, 65, 66, 68, 69
3	8	84, 85, 147
3	9	72 through 83
4	10	99 through 102
4	11	86 through 98
5	12	103 through 108, 115 through 126
5	13	109 through 114, 127 through 129
6	14	161, 163 through 168
6	15	148 through 155
6	16	156 through 160, 162
7	17	171, 175, 177, 178
7	18	169, 170, 173, 174
7	19	172, 176, 179, 180
6	20	181
7	21	191
7	22	182
3	23	183
2	24	184, 185
2	25	186, 187, 188
1	26	189, 190

Table 14
1966 Total Trip End Generation by Sub-Districts (All trips)

SUB-DISTRICT	1966 TOTAL TRIP ENDS	PERCENT OF TOTAL
1	65,655	15.6%
2	54,822	13.0
3	21,558	5.2
4	9,664	2.3
5	15,531	3.7
6	526	0.1
7	106,304	25.3
8	3,987	0.9
9	25,210	6.0
10	3,215	0.8
11	20,831	5.0
12	52,607	12.5
13	8,024	1.9
14	4,363	1.0
15	3,790	0.9
16	3,195	0.8
17	805	0.2
18	872	0.2
19	2,052	0.5
20	4,687	1.1
21	0	0
22	2,270	0.5
23	990	0.2
24	6,781	1.6
25	1,178	0.3
26	1,443	0.4
	420,360	100.0

Table 13
1966 Trips Between Planning Areas for All Purposes* (Non-directional)

PLANNING AREAS	0	1	2	3	4	5	6	7	Total
0	6,588	12,319	16,809	3,983	3,488	11,457	1,500	400	56,544
1		16,011	24,169	3,193	2,154	10,271	877	597	57,272
2			26,486	6,090	4,450	12,634	1,224	512	51,396
3				3,353	4,065	4,027	331	23	11,799
4					2,379	3,346	477	244	6,446
5						6,911	1,619	429	8,959
6							2,245	192	2,437
7								490	490
Total	6,588	28,330	67,464	16,619	16,536	48,646	8,273	2,887	195,343

*Includes internal auto driver and commercial trips only

Travel Patterns

Trips that were reported in the surveys were converted into an origin and destination table to determine the present desires of motorists. For the purpose of analysis the study area was subdivided into 180 internal analysis zones and 10 external stations, resulting in a trip table with 36,100 possible traffic movements. For the purpose of statistical summaries and comparisons, these 190 zones were compressed into 26 subdistricts. These 26 subdistricts were further compressed into the 8 planning areas used in other studies. The correspondence between planning areas, subdistricts and traffic analysis zones is shown in Table 12.

The trip table between all the 180 zones was compressed in a matrix of planning area movements. This matrix, illustrating the non-directional internal movements for all purposes, is shown in Table 13. The pattern of existing travel indicates that 70% of travel activity is in, and between, four areas. These areas (0, 1, 2, 5) include the CBD, CBD fringe, and the western section of the city. This relative distribution of trips will, no doubt, show substantial future changes due to the difference in relative growth rates in the various areas.

Currently the Central Business District accounts for almost 30% of all trip activity. This percentage should hold about the same in the future in light of the planning goal to maintain a strong city core area.

Finally Table 14 is a summary of all trips generated in each of the 26 sub-districts. This table indicates the relative importance of each area at a smaller level. The indication from this table is that over 25% of trips for all purposes are generated by sub-district 7. This district includes the area bounded by North 32nd Street, Grand Avenue, 17th Street West, and Montana Avenue.

4

Chapter 4

Development and Testing of the Travel Model

In order to provide decision makers with the necessary data to determine needed transportation facilities, it is first required to calculate the magnitude and distribution of future travel paterns. In recent years a number of procedures have been developed to forecast travel desires. These procedures usually follow the same general logical sequence. In a Bureau of Public Roads manual, this methodology was clearly explained by the following sequence of technical elements.

1. "Population and Economic Studies—what will be the magnitude of activities?
2. Land use—where will these activities be located?
3. Generation—how many trips will these activities generate?
4. Distribution—where will these trips go?
5. Mode Split—by which mode?
6. Assignment—which route will these trips take?
7. System Analysis—what is the best transportation system?"[1]

This section of the report explains the procedure used in this study for Elements 3 and 4, Generation and Distribution. The population, economic and land use studies were completed by the planning consultant and were used directly in subsequent processing. The consideration of mode split is not a major factor in the Billings area since transit usage is light.

The assignment and analysis elements are covered in other sections of this report.

Trip Generation

The purpose of trip generation analysis is to identify those parameters that are associated with the level of travel activity in the various traffic analysis zones. In this phase of the transportation planning process, it is attempted to establish a functional relationship between trip volumes and the socio-economic characteristics of the zones from which these trips originate or terminate. The method most often used to establish these relationships is the statistical analysis technique of "Multiple Regression." This methodology is, in effect, a mathematical procedure to measure the influence of such variables as population, vehicle ownership, employment, etc., on trips generated in the analysis zones. For example, it is evident that the number of work trips attracted to a zone will be in some way dependent on the employment in the zone. The regression analysis attempts to uncover the average extent to which these trips are associated with employment. When dealing with only two variables the process is relatively simple; however, in many cases there are a number of variables that affect the generation of trips, and the actual mathematical calculation can be quite cumbersome. For this reason multiple regression programs have been developed for use on high speed computers. These programs will accept a large array of data and produce a number of multi-variable equations that will best "explain" the generation of trips for various purposes. The type of program used in this study was of a step-wise nature. In this method, the variables are added successively in the order of their significance to the particular type of generation being tested. After each variable is added, statistical tests are made to determine the amount of improvement in the equation. If an added variable is later found by statistical test to have little correlation to trips under study, it is then dropped from the equation. Variables are continually added until all those specified are tested and a best final equation is produced.

For later use in gravity model procedures, trips are usually generated in terms of "productions" and "attractions" rather than origins and destinations. This means that trips are always produced at the home end of a journey regardless of whether this was the origin or destination of the trip. For example, a trip from home to work, followed by a later trip from work to home would be considered to generate two home-based work productions in the home zone, and two home-based work attractions in the employment area. The ten trip purposes originally collected in the survey were summarized into four basic general purposes. These general purposes were "Home Based Work", "Home Based Other", "Non-Home Based", and Commercial Vehicles. It was therefore necessary to develop six estimating equations, a production and attraction equation for the two home-based categories, one equation for Non-Home Based and a relationship for Commercial Vehicles.

It is not required to compute separate production and attraction equations for non-home based and commercial trips. For these two categories the productions and attractions are the same as origins and destinations and are approximately equal.

The variables that were tested in the course of this analysis were as follows:

1. Population
2. Total Dwelling Units
3. Total Employment
4. Vehicle Ownership
5. Single Family Dwelling Units
6. Multi Family Dwelling Units
7. Employment in Manufacturing Industries
8. Employment in Transportation and Utility Industries
9. Employment in Wholesale-Retail Industries
10. Employment in Finance, Insurance and Real Estate Industries
11. Employment in Service Industries
12. Other Employment
13. Student Enrollment

Of these thirteen available parameters, eight passed the necessary statistical criteria to be included in one or more of the final equations.

For the first trial, data for the 180 internal traffic analysis zones were used as input and a series of regression equations were developed. During the stepwise buildup of the regression equations, the statistical test of standard error and correlation were carried out. The standard error is a measure of the difference between the actual data points and the values as computed by the derived equations. The correlation test is a measure of the degree of association between the dependent variable (trip generation) and the independent variables (socio-economic factors).

The equations developed in this first trial showed a high degree of correlation between the variables; however, it was felt that the standard error of estimate was too high. It was concluded that this set of equations could not be used with enough confidence for future projections and an alternate procedure should be investigated.

An alternate methodology was attempted whereby a number of observations which were thought to contain unstable data were removed from the analysis. These deleted observations included zones which presently do not contain urban characteristics in undeveloped or fringe areas, and areas with low population and/or employment totals. The resulting regression equations showed some improvement over the previous trial; however, the degree of improvement was still considered inadequate.

For a third trial procedure all the available data was aggregated to a larger zonal structure. The 180 internal zones were compressed into 42 super-zones of more or less homogenous characteristics. The regression programs were then rerun with significantly better results. The developed equations demonstrated a substantial improvement in the standard error of estimate and additional improvement in the correlation measures. A number of trials were run for each trip purpose utilizing various combinations of variables. The final estimating equations that were selected are as follows:

Home Based Work Productions
$$= 0.31P + 39$$
Home Based Work Attractions
$$= 0.64E + 143$$
Home Based Other Productions
$$= 4.93S + 2.05M - 230$$
Home Based Other Attractions
$$= 2.35W + 2.05V + 2.59\varnothing + 1.82D - 552$$
Non-Home Based
$$= 0.35P + 1.13E - 240$$
Commercial Vehicles
$$= 0.20P + 0.75E + 101$$

Where:

P = Population
E = Employment
S = Single family dwelling units
M = Other dwelling units
W = Employment in wholesale-retail trade
V = Service employment
$\varnothing$ = All other types of employment
D = Total dwelling units

These equations all showed a correlation coefficient between 0.94 and 0.98. Since a value of 1.00 is a perfect correlation, these values would indicate a high association between the selected parameters and trip generation. The standard error of estimate ranged from a value of 19% for home based work productions, to a high of 35% for home based other attractions. The overall average error, considering the total of all trip purposes, would average about 25%. It would be desirable to reduce all the standard errors to below 25% for each purpose, but this was not considered possible unless many more socio-economic factors were available for introduction into the various equations. Although data for other factors may be available for the 1966 base year, it would be a difficult task to forecast parameters, other than those used in this analysis, for the study year of 1990. The variables actually used in these equations better lend themselves to future prediction within the framework of the area planning goals.

Following the completion of regression analysis, the developed equations were applied to the 1990 predicted population and employment estimates. These estimates were forecasted by the planning consultant to afford compatibility between the transportation study and the Comprehensive Plan.[2] Generally the level of activity for the forecast year of 1990 was about twice that for the base year of 1966. Table 15 illustrates the comparison of the various parameters for the two years.

Application of the regression equations to the 1990 data gave rise to one additional problem that had to be resolved. These equations were based on data from 42 super-zones, while the 1990 generation was required for each of the 180 internal zones.

Utilizing these equations at the zonal level could lead to substantial errors. To overcome this problem, the following logical procedure was devised. First, the equations were used to estimate the generation at the super-zone level. This generation was considered to be a control total for the area and was then distributed to the individual zones in accordance with the pertinent parameters for the given trip purpose. This procedure can be illustrated by the following example for commercial vehicle generation.

$$Ci = (.20\,Ps + .75\,Es + 101)\ \frac{.20\,Pi + .75\,Ei}{.20\,Ps + .75\,Es}$$

Where:

Ci = Commercial Vehicle generation at zonal level
Ps = Population in super-zone
Es = Employment in super-zone
Pi = Population at zonal level
Ei = Employment at zonal level

This methodology was followed for each purpose.

The trips generated by the external stations cannot be estimated by the previously described method. This generation was estimated by the Montana Highway Commission. The total trips at each external point were distributed to the various trip purpose in the same proportion as found for the base year.

The final step to complete the trip generation phase of the study was to total and compare the sum of productions and attractions for each purpose. For any given purpose, the total productions must theoretically equal the total attractions. The raw totals as produced by the estimating equations and the external estimates showed a slight discrepancy of five to seven percent difference in these totals. The parameters of population and dwelling units are usually considered more reliable for future estimations than employment and employment types. Therefore, the totals yielded from the production equations were assumed to be more accurate and the attractions were adjusted to conform to this sum.

Table 15
Comparison of 1966 and 1990 Population and Employment

	1966	1990	PERCENT INCREASE
Population	73,652	149,100	102%
Dwelling Units	23,345	46,760	101
Single Family Units	17,024	32,985	93
Other Type Dwelling Units	6,321	13,775	118
Total Employment	28,768	51,246	79
Wholesale-Retail Employment	7,601	14,550	91
Service Employment	6,214	11,050	78
Other Employment	14,953	25,638	72

1 Guidelines for Trip Generation Analysis, U.S. Department of Transportation/Federal Highway Administration, Bureau of Public Roads, June 1967.
2 Comprehensive Plan of the Billings Planning Area—Clark, Coleman & Rupeiks, Inc. Dec. 1968.

Trip Distribution Model

The trip distribution phase of the transportation study is the process whereby the trips generated in the various zones are linked together yielding an overall pattern of future travel. The object of this task is to eventually build a forecast year trip table to accurately reflect the travel desires between areas of activity.

There are a number of so called traffic models now in existence to accomplish this purpose. Probably the two most common techniques now in use are the "Fratar Method" and the "Gravity Model".

The Fratar Method was used in the previous Billings Transportation Study. This methodology estimates future trip interchanges based on average expansion factors applied to the existing distribution. This procedure has one imporant disadvantage in that it cannot forecast interchanges between zone pairs that have little or no base year activity. These zones require a separate forecasting procedure. In the previous study, the number of zones falling into this category was small and the Fratar Method could be used with confidence. In the current study, the number of zones exhibiting little activity was much greater due to the expansion of the study area limits. For this reason, it was decided that the Gravity Model would yield a more reliable future traffic pattern.

The Gravity Model postulates that the number of trips between two areas is directly proportional to the activity in each area and inversely proportional to the time separation between the areas. This statement is similar to the laws of physical gravitation, hence the name. The theory simply states that trip interchanges between zone pairs tend to increase with the generation of the zones, and decreases as time or distance separation increases.

The first task in the development of this model is a calibration technique based on existing data. Essentially, the purpose of calibration is to measure the effect of time separation on trip frequency. This time effect is expressed as a series of pure numbers, usually called friction factors, for each increment of time, for various trip purposes. They are actually an expression of trip occurrence probability for each travel time increment by purpose.

For the first trial of the calibration these probability factors are assumed to be 1.00. This is, in effect, saying that time has no influence on trip interchanges. With the time factors all set at 1.00 a synthetic trip table is built. Under this assumption the trip table simply becomes a distribution based on zonal activity. For example, if the Central Business District contains 15% of the total area trip generation for a given purpose, it will then attract 15% of the trips for that purpose from each of the zones in the study area, regardless of the location of these zones with respect to the CBD. The synthetic table is then converted to a trip frequency distribution, that is, the total trips occurring in each time increment are

summed. From the base year travel survey data, a trip table is built to reflect the actual existing travel desires. This trip table is also converted into a frequency distribution. From the comparison of these two tables the effect of time can be computed based on the ratio of actual to synthetic trips for each interval of time. The new set of factors is then substituted in place of the original assumption of 1.00 for each time increment and a new synthetic distribution is developed. This new table is again compared to the actual table and a further revision of the time factors is calculated.

The process is repeated as many times as necessary until certain statistical measures indicate that the model can reliably reproduce the actual trip distribution within certain accuracy limits. For this study, the actual frequency distribution was successfully synthesized after the third trial. The degree of error considered acceptable in the calibrations was 3%, which means the calibrated gravity model must predict the number of trips within plus or minus 3% for 90% of the time intervals.

The accuracy and reasonableness of the gravity model can be tested in a number of ways. These checks are listed as follows:

1. Comparison of the actual and synthetic trip frequency distribution
2. Comparison of actual and synthetic average trip time duration
3. Comparison of actual and synthetic district to district trip movements
4. Comparison of the time friction factors with factors developed in other areas of somewhat similar size and characteristics.

The comparison of the actual and synthetic frequency distribution is shown in Table 16. The synthetic average trip length as compared to the actual is shown below:

PURPOSE	ACTUAL AVERAGE TRIP LENGTH	GRAVITY MODEL TRIP LENGTH
Home Based Work	11.3 minutes	11.4 minutes
Home Based Other	9.4 minutes	9.7 minutes
Non-Home Based	9.6 minutes	9.9 minutes
Commercial Vehicles	9.2 minutes	9.5 minutes

The comparison of the actual and synthesized trip tables, compressed to the eight planning areas is reproduced in Table 17. The table shows an average error in trip movements between districts of 14 percent. This would indicate that even if some large percentage errors are present in individual zone to zone movements, the overall travel desires between larger areas are successfully reproduced. It is these larger area-wide demands that would affect the traffic network needs in the major travel corridors.

Table 16
Comparison of Trip Survey and Gravity Model Frequency Distribution

TIME (Minutes)	HOME BASED WORK		HOME BASED OTHERS		NON HOME BASED		COMMERCIAL VEHICLES		TIME (Minutes)
	Actual	Model	Actual	Model	Actual	Model	Actual	Model	
1	0	0	0	0	0	0	0	0	1
2	0	0	0	0	34	50	47	62	2
3	199	247	2,556	2,774	1,428	857	2,324	1,822	3
4	488	361	4,119	3,549	1,557	1,113	1,753	1,491	4
5	753	612	5,494	4,621	2,141	1,909	2,818	2,316	5
6	1,128	1,022	6,842	7,039	3,744	2,996	2,900	2,610	6
7	1,418	1,497	9,146	8,407	4,089	4,206	2,431	3,289	7
8	1,643	1,807	8,762	8,666	4,491	5,218	3,501	3,793	8
9	2,145	2,214	9,193	9,334	6,563	7,812	5,421	5,362	9
10	2,468	2,367	9,075	8,766	6,477	6,559	4,683	4,778	10
11	2,161	2,291	7,000	7,388	4,567	5,331	4,057	4,187	11
12	2,289	2,188	5,960	5,948	3,312	3,420	2,823	2,974	12
13	2,203	2,091	5,943	5,743	3,529	2,965	2,453	2,381	13
14	1,331	1,492	3,104	3,397	1,870	1,751	1,470	1,512	14
15	1,257	1,291	2,799	2,815	1,405	1,276	1,242	1,192	15
16	1,207	1,196	1,626	2,272	1,164	972	780	922	16
17	895	869	1,367	1,741	787	703	539	698	17
18	683	628	802	1,129	325	332	478	305	18
19	268	306	276	482	184	140	64	80	19
20	119	195	328	275	18	74	0	12	20
21	184	115	124	158	6	46	9	6	21
22	77	85	120	126	66	30	0	0	22
23	17	40	116	65	0	13	0	0	23
24	0	29	12	39	0	8	0	0	24
25	51	24	0	26	34	7	0	0	25
26	0	11	11	9	0	1	0	0	26
27	0	4	0	2	0	0	0	0	27
28	0	2	0	2	0	0	0	0	28
29	0	0	0	0	0	0	0	0	29
30	0	0	0	0	0	0	0	0	30

Table 17
Origin Destination Survey vs. Gravity Model For Planning Area Traffic Movements

PLANNING AREAS								PLANNING AREAS
0	1	2	3	4	5	6	7	
6,588	12,319	16,809	3,983	3,498	11,457	1,500	400	0
6,021	11,005	16,353	5,129	4,874	10,998	2,054	681	
	16,011	24,169	3,193	2,154	10,271	877	597	1
	14,351	26,372	3,589	2,885	11,041	1,548	446	
		26,486	6,090	4,450	12,634	1,224	512	2
		24,129	8,359	5,123	11,976	1,795	667	
			3,353	4,065	4,027	331	23	3
			2,428	2,523	3,213	503	238	
				2,379	3,346	477	244	4
				1,519	3,617	656	272	
					6,911	1,619	429	5
					7,102	1,998	553	
Actual Trips						2,245	192	6
Gravity Model Trips						956	234	
							490	7
							136	

The comparison of the calibrated friction factors with factors from other cities is depicted in Figures 12 through 15. The cities for which data was available are Cedar Rapids, Iowa (population 137,000), Ogden, Utah (population 111,000) and Sioux Falls, South Dakota (population 87,000). These areas were selected due to their location (middle or mountain area of the country) and relative size (under 200,000 population). The factors developed for Billings closely resemble those of Cedar Rapids.

To interpret the meaning of these factors consider the Billings factors for work trips. At thirty minutes the factor is 4.0 and at five minutes the factor is about 16.0. This means that if all other things were equal, an employment location should attract 4 times as many trips from areas within five minutes travel time than from those areas thirty minutes away.

Since the Central Business District is the most important single attraction of work trips, a more detailed comparison of actual and estimated trips to this area was developed. This comparson, shown in Table 18, depicts traffic movement between the 19 internal sub-divisions and the CBD for home based work trips. The table indicates a reasonably good comparison between the synthetic and actual trip movements.

Following the satisfactory development of a gravity model for distribution, and a set of estimating equations for generation, the next step in the transportation planning process is the development of the forecast year trip pattern. Essentially this phase ties the two tasks of generation and disribution together to produce an estimate of 1990 travel desires.

Before a distribution can be performed, a future highway network configuration must be assumed for the determination of travel times between zones. A trial future network was delineated by the Technical Advisory Committee and was used as a basis of the trip distribution. This assumed highway system was coded and the minimum time routes between all zones was calculated by computer processing. A number of these minimum paths or "trees" were hand plotted to uncover any illogical routings or other errors in the network. When the network was found to be free of errors, a so-called skim tree program was run. This program is a summary of all zone to zone travel times plus terminal times. Terminal time is the difference between "door to door" time, and actual "over the road" driving time. The gravity calibration was based on estimated door to door times.

Figure 12
Friction Factor Comparisons Home Based Work Trips

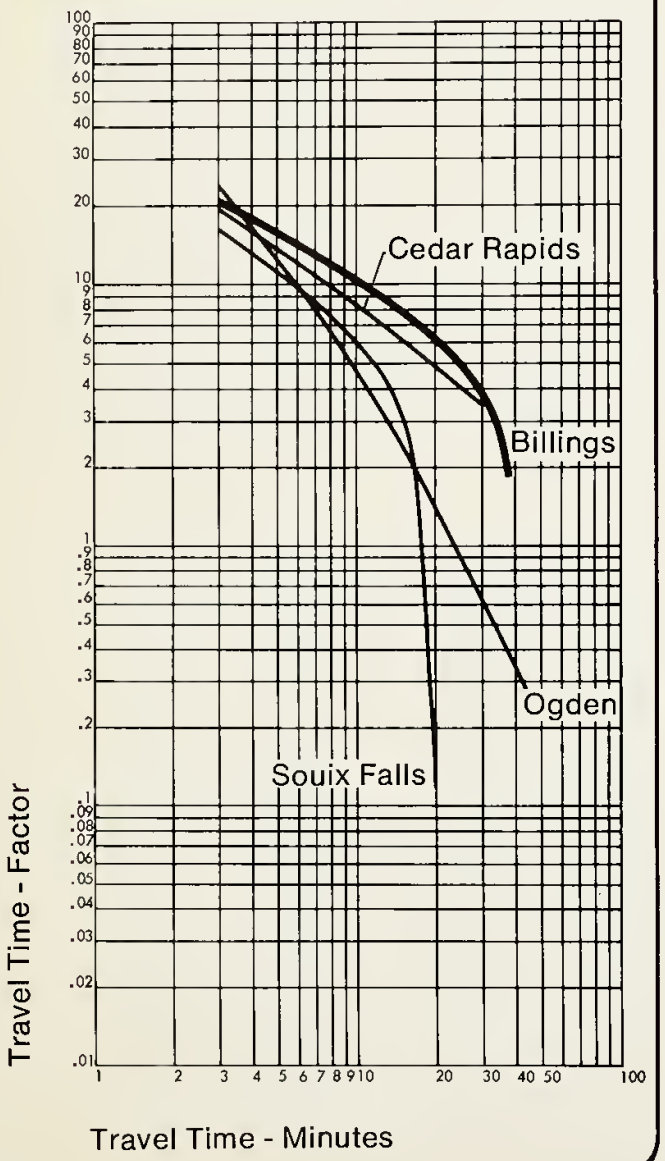


Figure 13
Friction Factor Comparisons Home Based Other Trips

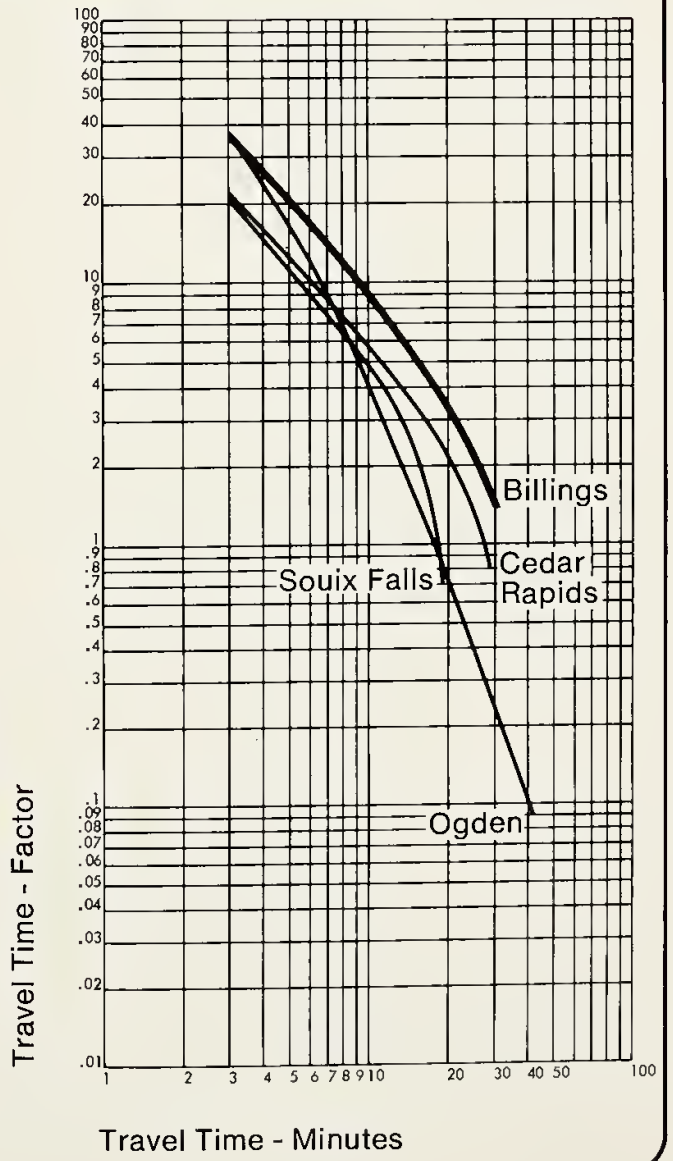
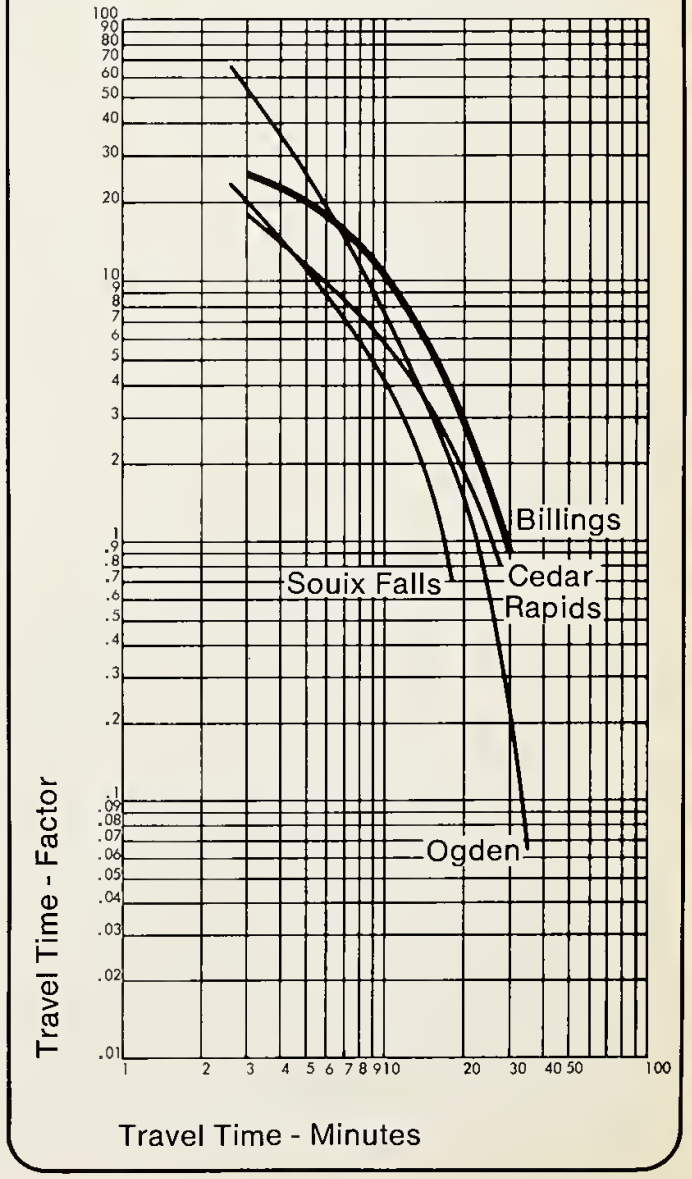


Figure 14
Friction Factor Comparisons Non Home Based Trips



These skim tree time values, together with the friction factors as determined in the calibration phase, and the 1990 trip productions-attractions from the generation phase constitute the necessary input data for a forecast trip distribution. Finally, the gravity model program was run with these inputs and a 1990 trip table was built. For the purpose of comparison, this table was compressed to illustrate the estimated trip movements between the major planning areas for the forecast year. The summary, with the 1990 trip interchanges and relative change from the base year, is presented in Table 19.

It is of some interest to note the change in average trip duration between 1966 and 1990. The 1990 average trip length is as follows:

Home Based Work Trips	15.0 minutes
Home Based Other Trips	13.2 minutes
Non-Home Based Trips	11.5 minutes
Commercial Vehicle	11.7 minutes

These trip lengths are from about two to four minutes greater than in 1966, with the home-based trips exhibiting the greater increase. This reflects an urban development of Billings in agreement with the planning goals. Under the concept of a "strong" Central Business District, the development of population centers in more outlying areas would require longer trip lengths to the city core.

One classification of trips that cannot be determined by gravity methods is the through trips between external stations. These trips were calculated by applying the average expansion of the two externals involved to the base year through trips.

These trips, when added to the gravity output complete the forecast year estimated travel desires.

Figure 15
Friction Factor Comparisons Commercial Vehicle Trips

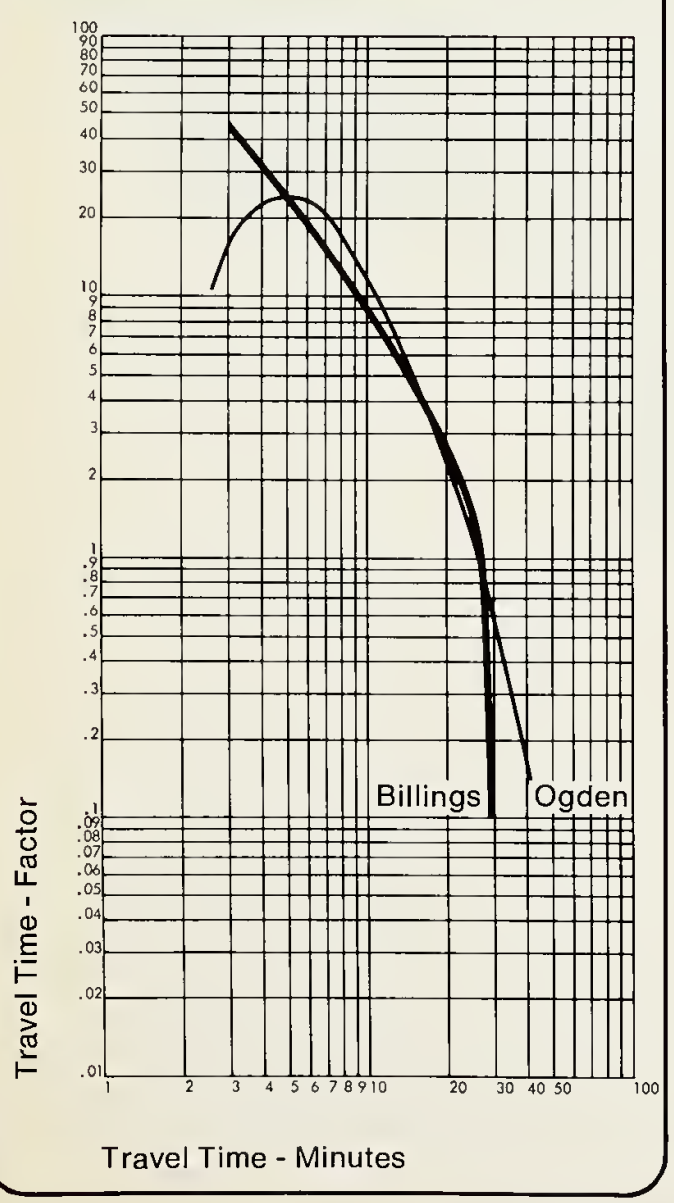


Table 18
Origin-Destination Survey vs. Gravity Model for Movements to CBD by Internal Sub-Districts

SUB-DISTRICT	HOME BASED WORK TRIPS O D Survey	HOME BASED WORK TRIPS Gravity Model
1	53	91
2	1,132	860
3	396	340
4	254	225
5	563	395
6	0	2
7	1,962	1,767
8	23	80
9	512	614
10	84	65
11	141	362
12	531	625
13	11	19
14	122	193
15	95	141
16	155	178
17	12	70
18	0	0
19	78	89
	6,124	6,116

Table 19
Trip Interchanges Between Planning Areas 1990 Average Daily Trips

PLANNING AREAS	0	1	2	3	4	5	6	7
0	12,803 1.94	19,954 1.61	27,624 1.64	8,818 2.22	7,692 2.21	13,196 1.14	15,628 10.40	10,008 25.00
1		18,834 1.17	32,194 1.33	4,740 1.48	4,022 1.87	11,174 1.08	9,116 10.35	6,406 10.72
2			34,270 1.30	11,832 1.95	6,934 1.56	11,790 .93	9,486 7.75	7,652 14.95
3				3,566 1.06	3,452 0.85	3,390 0.84	2,856 8.61	2,678 116.00
4					2,044 0.86	3,582 1.07	4,420 9.27	3,580 14.70
5						4,864 0.70	9,404 5.81	5,856 13.69
6							12,497 5.56	9,170 47.90
7								8,012 16.40

00,000 1990 Trips
0.00 Growth Factor 1966-1990

5

Chapter 5

Plan Testing and Evaluation

Following the establishment of a reasonable estimate for 1990 travel patterns, the next phase in the planning process is the determination of a network system that will best serve these anticipated demands. The accomplishment of this goal involves, first, the identification of future problem areas in terms of traffic flow, second, the testing of various network improvements to relieve these critical areas, and finally, the evaluation of alternate plans with regard to engineering feasibility, public acceptance and benefits, and overall improvement of traffic movement.

In order to identify those areas that are most likely to cause future congestion, the 1990 trip desire pattern was assigned to a "Basic Network". This base system consisted of the street and highway network as it existed in 1966, with the addition of a few arterials and collectors that would probably be constructed under any circumstances as a normal part of the city growth. This particular network would be the system that would evolve under a "do nothing" policy.

The purpose in dealing with the Basic Network first is two fold: first, the areas of critical traffic demand can be readily identified, second, this network will constitute a system to which all other alternates can be compared when measuring benefits to the highway users.

Critical Areas

The initial loading of 1990 trips dramatically pointed up a number of locations of excessive traffic demand. These areas, that will be described in this section are by no means the only areas that should be considered for improvement; they are, however, the areas in the street and highway network that would most likely cause a breakdown in the transportation system at some future date. These particular problem locations, if no provision for improvement is made, would be subject to intolerable delays such as found today in larger urban areas, especially during peak periods.

East-West Flow

This area will be analyzed on an overall corridor flow basis first, rather than on an individual street analysis. The corridor referred to here includes the five major arterials that carry traffic from west Billings area into, or through, the Central Business District. The included arterials are Central Avenue, Broadwater Avenue, Grand Avenue, Poly Drive and Rimrock Road. The current traffic demand in this east-west corridor varies from 30,600 vehicles in the vicinity of 17th Street West to 50,700 at the intersection with 6th Street West. In 1990 the traffic demand would increase to 54,500 and 83,800 at those locations or over a 70% average increase. For the corridor as a whole this would represent a traffic demand of approximately 30% more than the available capacity. Actually, for certain individual streets, the situation would be worse than the overall corridor deficiency, since the growth in traffic demand is not uniform on each of the east-west facilities. The highest growth will be in the southern (Central Avenue) and northern (Poly-Rimrock) areas of the corridors. These facilities would exhibit a much greater capacity deficiency than the Grand-Broadwater corridor.

Another facility in this general area that will be a major future problem is Montana Avenue, between the intersections of Central and Division Streets. This arterial at present carries about 14,000 vehicles per day. The 1990 traffic assignment revealed a potential demand of over 30,000 vehicles per day. This would represent a traffic flow of about 50% above the current capacity.

Fairgrounds Area

Because of the projected high growth rate of the Heights Area, the maintained strength of the Central Business Districts and the geography of the area, the highest projected traffic volumes are to be found along Exposition Drive by the Fairgrounds. As reference to any Billings street map will show, Exposition Drive just north of 6th Avenue North forms a natural geographic "bottleneck". There is no other logical route at this time for traffic from the Heights area to reach either downtown or the Lockwood area. Exposition Drive currently carries daily a volume of from 17,000 at 6th Avenue North to 10,000 at 1st Avenue North. The 1990 indicated demand on this arterial was close to 60,000 ADT. This volume represented the highest loading on any link in the entire network, including Interstate 90. A demand volume of this magnitude is beyond the carrying ability of any conventional arterial and is in the range that would require some type of limited access facility.

The "Heights" oriented traffic, when mixed with other traffic between Downtown and the Lockwood area, causes additional problems on 1st Avenue North and Hardin Road. Especially critical is the Hardin Road Bridge across the Yellowstone River. The traffic demand for this substandard two lane bridge is 44,000 vehicles per day. A volume in this range would justify at least a four lane or preferably a six lane freeway.

To illustrate the source of the overloads on Exposition Drive, Figure 16 was developed to show the 1990 distribtuion of traffic for vehicles using the section of Exposition Drive just north of 6th Avenue North.

Figure 16
Distribution of Exposition Drive Traffic

Central Business District

In order to maintain a viable downtown area, adequate circulation must be provided. The 1990 assigned volume indicates that the greatest increase in traffic will occur on the north-south flow corridor. The arterials between and including North 30th to North 27th Streets are now carrying a little more than 25,000 vehicles per day. This flow is projected to increase 70% by 1990 for a demand of over 42,000 vehicles per day.

The east-west flow demand in the CBD will show a more modest increase in demand, on the order of 40%. However, this amount of traffic will also tend to further impair circulation when it conflicts with the north-south demand at major intersections.

Network Testing

A number of network improvements were proposed for the relief of the previously described critical areas. These improvements were coded into the Basic Network and an analysis of their economic and traffic relief benefits were made. The general methodology used in this portion of the planning process was to add improvements in a stepwise manner, building up to an overall improvement program. By this procedure it is possible to isolate and study the effects and benefits of individual actions, rather than the testing of one large scale improvement program.

To evaluate any transportation plan, some consideration must be given to the economic traffic service benefits that would result from a given course of action. To justify any proposed facility it must be shown that the accrued benefits are in excess to the necessary capital investments. A generally accepted method to measure these benefits is in terms of vehicle operating cost savings and time cost savings.

From available research data and publications a procedure was developed to measure these operational and time benefits. Vehicle operational costs were identified for eight various types of facilities based on geometric design and/or running speeds. An additional estimate was made for the value of time saving to the motorist. The time value in this study was purposely estimated on the conservative side. It is rather difficult to estimate just what dollar value an individual places on time saving. It is probable that this value will vary with the purpose of the trip and the economic status of the individual. The time value represented here is about a minimum estimate.

Other considerations that are not reflected in these evaluation estimates are accident costs and the higher operating cost of commercial vehicles.

Table 20 shows the various operational costs used in this study. Each link in the highway network was assigned a code number that identified it in one of the eight classifications. Following the assignment of the 1990 trip table to the Basic Network, a tabulation of total vehicle-miles and vehicle-hours were obtained and converted into cost data. As various proposed improvements were added, a new tabulation of total operating and time cost were produced and compared to the base system. The reduction of these total costs constitute a measure of public benefits. The stepwise building of a future system permitted an analysis of benefits accredited to each separate improvement. These benefits are then accrued over a twenty year period and compared to the capital cost of each project to determine the relative value of benefits in relation to the costs.

Table 20
Highway User Operational & Time Costs

CODE	DESCRIPTIONS	COST PER VEHICLE MILE (Cents)
0	Freeway	4.5¢
1	High Type Divided Arterial	5.2
2	One-Way C.B.D. Couplets	8.0
3	Conventional Highways—Speed over 35 mph	5.5
4	Arterial—Speed 30 - 35 mph	6.4
5	Arterials, collectors—Speed 20 - 29 mph	7.8
6	All Facilities—Speed 15 - 19 mph	8.3
7	All Facilities—Speed less than 14 mph	9.5

Time Value = 3.4¢/Min. or $2.04 per Vehicle Hour

Alternate Testing Results

The first project added to the Basic Network was the installation of a Couplet System in the Central Business District and an upgrading of 1st Avenue South. By augmenting the capacity and standard of 1st Avenue South, it was possible to divert approximately 40% of the traffic from Montana Avenue. A diversion of this magnitude would be sufficient to reduce the traffic on Montana to a workable level.

The couplet system in the Central Business District included North 27th-25th Streets and Montana-1st Avenue North. The traffic demand in these corridors would be the same, with or without the couplet system, however, this one way operation will carry the demand more efficiently and provides many other benefits. The benefits of a one-way couplet operation were covered in detail in the previous transportation study. These advantages are briefly summarized as follows:

1. Better distribution of traffic between an overloaded and under-used facility.
2. Some parking, which may be removed on a two-way street, can possible be retained on the one-way streets.
3. Cost is less than attempting to increase existing system capacity.
4. Delays are greatly reduced due to the reduction in the number of turning conflicts and better signal timing.
5. Overall operation shows a significant increase in safety.

The next step in this testing procedure was to add an improved north-south facility in the west Billings area. Although it was not brought out in the discussion of critical areas, there is a definite lack of a continuous north-south route in this area. In the corridor between 13th and 24th Street West, there is a current demand of 12,000 vehicles per day in this direction. This traffic will increase approximately 50% by 1990. To help meet this demand, an upgraded continuous route was assumed in the vicinity of 16th and 17th Streets West. This alignment provided more direct service from the west interchange of Interstate 90 on the south, to Rimrock Road on the north. A facility of this type would carry a 1990 traffic volume ranging from 16,000 vehicles per day in the vicinity of Central Avenue, to a maximum of 22,000 just south of Rimrock. By providing an improved carrier such as this type of facility, traffic would be diverted from other

north-south streets in the area, allowing these lesser facilities to retain their neighborhood local street characteristics.

Following the establishment of this 17th Street West facility, it was decided that the next logical improvement of the system would be the extension of the arterial up to the Rims connecting with Montana Route 3. Inherent in the addition of this link was the improvement of Route 3, due to the added traffic induced by the 17th Street facility. These improvements would include highway widening and an improved intersection, or interchange, at the Airport. The major advantage of this connection to the Rims was in the amount of traffic that would be diverted from Poly and Rimrock Drive. It is estimated that an efficient bypass route via the Rims could reduce the traffic demand on the Poly-Rimrock corridor by 50%, greatly reducing the amount of widening required on these two facilities. However, the construction of this link would pose a formidable engineering problem.

An additional plan proposed for a Rim connection was to make use of the existing Zimmerman Trail with improvements in alignment and geometrics. The 1990 trip table when loaded to this network resulted in a loading of 20,000 vehicles per day on the link connecting to the Rims, and a diversion of 27% from the Poly-Rimrock Corridor. In comparison, the 17th Street West to Rims connection carries a volume of 37,000 with a 50% diversion from the Poly-Rimrock Corridor.

In the critical areas of Exposition Drive and Hardin Road, two possible solutions were tested. First, a full freeway section was assumed from the intersection of Lake Elmo Drive and Route 87 to connect with Interstate 90 south of the Stockyards. This alignment would follow the existing Route 87 to just north of 6th Street North, then parallel Exposition Drive to the west, providing ramp connections to the major east-west streets and preserving the existing Exposition Drive for local circulation into and around the Fairgrounds. The major advantages of this type of facility was to provide the required capacity for the bottleneck condition on Route 87, and the removal of 80% of the traffic demand from the Hardin Road Bridge.

An alternate solution to the Exposition Freeway is a proposal to link the Lockwood interchange of Interstate 90 with Route 87 at the intersection of FAS 318. This facility was envisioned as a high type arterial or expressway where running speeds of 45 miles per hour were attainable. A facility of this type on this alignment would divert 68% of the traffic demand from the Hardin Road Bridge and 40% of the traffic from Exposition Drive. Although this is a considerable amount of diversion, it would not preclude some expenditures for the improvement of these two facilities. The advantages of this link is that it provides a direct connection between the Heights and Lockwood area, it is probably less disruptive than a freeway, and is less expensive to construct. The relative merits of these two possible solutions are covered in detail in the "Recommendations".

The next network to be tested assumed an improved Grand Avenue. This alternate was loaded with 1990 trips to determine if additional diversion from the Rimrock-Poly or Central corridors was possible. The traffic loading resulted in only a small amount of diversion from these corridors; most of the additional traffic loaded to Grand was diverted from Broadwater. Although it was not possible to divert traffic from other corridors, it was felt that some improvement of Grand Avenue would be necessary in any case due to the total traffic demand in this corridor. Another improvement that would increase the efficiency of traffic flow in conjunction with Grand Avenue improvements is the conversion of North 32nd and Division Streets into a set of couplets. (This was originally proposed in the first De Leuw, Cather report.) This couplet would provide a system to connect the Grand Avenue traffic to the downtown east-west couplets.

Finally a network was tested which included a tunnel connection from the Central Business District fringe area and FAS 318, east of the Airport. This particular improvement exhibited only nominal diversion from other overloaded corridors. The disadvantage of this project is that it will induce additional traffic volumes into the North 27th Street north-south flow, which will be loaded close to capacity by 1990. This facility will also present some major economic and engineering problems which will be detailed later in this study.

Two other assignments were made for the purpose of economic comparisons only. These additional networks included a full system with the deletion of the 17th Street Rims connection, and the same full system with a portion of the Exposition Freeway between 1st Avenue and Interstate 90 deleted. By summarizing vehicle operating cost from these assignments, it was possible to isolate the economic value of these links.

A loading of an ultimate transportation plan to be included in the Comprehensive Plan Study was also completed. The major feature of this network was the inclusion of the so-called Belt Concept. This assumed a freeway faciltiy parallel to Shiloh Road with a connection to the Rims. This freeway, together with an improved Route 3 and an Exposition Freeway or Lockwood Connection would complete a loop around the Billings urbanized area. The 1990 traffic assignment showed rather light loadings on the western side of this belt system, indicating that this facility would probably not be needed until sometime after the 1990 target date of this study.

This completed the testing of various network configurations. As previously mentioned, a summary of vehicle-miles and vehicle-minutes was summarized after each run and converted into a 20 year operating cost. These costs, when compared to the Basic Network costs, give some indication of the user benefits for each alternate proposal. A summary of each tested network and twenty year user benefits are presented in Table 21. At this point, it should be noted that these systems cannot be fully evaluated until the benefits are compared to the construction and right of way costs. However, the benefits shown in Table 21 do give indication of the relative value of traffic service inherent in each of the proposed plans.

Table 21
Twenty Year* User Savings for Tested Networks

NETWORK ALTERNATE	DESCRIPTION	TOTAL 20 YR. USER COST (Millions)	INCREMENTAL 20 YR. SAVINGS (Millions)	TOTAL NETWORK USER SAVING (Millions)
Basic Net	1966 system plus new arterials included as part of normal growth	1247.5	—	—
A	Basic, plus C.B.D. couplets, improved First Avenue South	1232.0	15.5	15.5
B	Network A, plus 17th Street West arterial from King Ave. to Rimrock Rd.	1224.8	7.2	22.7
C	Network B, plus 17th Street West connections to Rims	1200.4	24.4	47.1
D	Network A, Plus Grand Avenue improvement, Division-32nd Street couplet	1212.1	19.9	35.4
E	Network C, plus Exposition Freeway to I 90	1187.4	13.0	60.1
F	Network C, plus connection FAS 318 to Lockwood Interchange	1186.5	13.9	61.0
G	Network E, replace 17th St. W. to Rims with improved Zimmerman Trail route	1185.6	26.2	61.9
H	Network A, plus Tunnel from CBD Fringe to FAS 318	1220.6	11.4	26.9

*Economic comparison period assumed from 1975 to 1995

6

Chapter 6

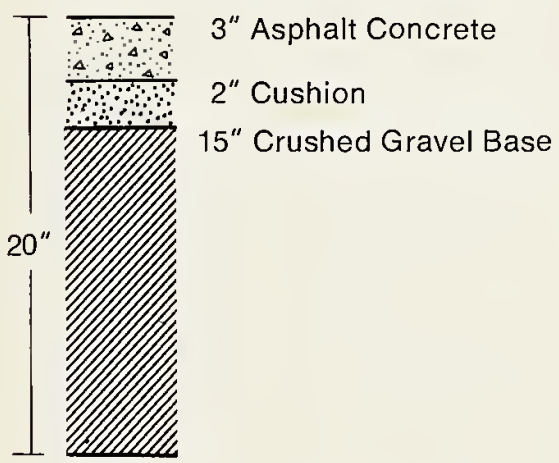
Preliminary Engineering and Cost Data

In the previous section of this report various network alternatives were tested for their traffic service and user benefits only. The next task in the transportation planning process is to estimate the cost of various proposals so that a comparison of costs and benefits can be used as a decision making tool. Costs were analyzed in detail for all the projects previously described in Chapter V.

Basic Assumptions

Cost estimates were based on 1968 bid prices furnished by the Montana State Highway Department and recent cost data received from the city. They include an allowance of 30% for design, construction engineering and contingencies. Costs for right-of-way were obtained from the Montana State Highway Department. In addition, the following general assumptions were made with regard to type and method of construction:

1. Existing pavement on the recommended arterial street system which appears on visual inspection to be structurally unsound will be removed and replaced by new pavement.
2. In instances where widening is required, where the existing pavement is to be replaced, or where there is no existing pavement, a new sub-base course will be provided together with a new base and surface course as shown in the following sections:



3. On arterial streets that are to be repaved, the existing surface will be retained as a base and resurfaced with a tack coat and a three inch layer of asphalt concrete. If this causes a substandard grade condition on adjacent sidewalks, such walks will be improved and brought up to grade.
4. Sidewalks, trees and other obstructions will be removed, as required, for the widening of existing streets.
5. New curbs and gutters will be constructed of Portland cement concrete.
6. New concrete sidewalks will be five feet wide.

Preliminary Engineering

All the possible alternate solutions were reviewed with respect to engineering-financial feasibility as well as other factors such as community impact and public acceptance. In two instances, proposed improvements were eliminated from further consideration by factors other than traffic service.

One of these rejected proposals was the extension of 17th Street up to the Rims. Preliminary engineering studies revealed that the best route would begin at Rimrock and 17th Street, turn right north of Rimrock Road, slicing through the northwestern portion of the Morledge subdivision, and then head east up the face of the cliff. There were three objections to this plan. One, it would cut an area of beautiful homes in two, in the process removing twenty-two homes. Secondly, a terrace would be cut diagonally up the cliff, defacing a beautiful city landmark. Thirdly, there existed the possibility of rock slides during and after construction. For these reasons the plan was dropped, and an alternate Rim connection was proposed. This alternate would make use of the existing Zimmerman Trail with improvements in alignment and geometrics. This solution does not provide as much traffic service as the 17th Street connection, but it was felt that this facility would be less disruptive to existing neighborhoods and would cause only a minimum defacement of the cliffs.

Another plan rejected because of economic problems was a proposed tunnel connecting downtown Billings and U.S. Highway 10, 12 & 87, north of the Fairgrounds. The tunnel's southwesterly terminal begins at the intersection of 12th Avenue North and North 22nd Street. At the other end, the tunnel could exit either at Alkali Creek Road, or at State Secondary Highway 318. The former alignment results in a shorter tunnel and better profile. The cost of tunneling the twin bores would be about $15 million. In addition, about $15,000 a month will be required to maintain the ventilation and other mechanical equipment in the tunnels. A connection would have to be built from the northeasterly end of the tunnels with U.S. 10, 12 & 87. This could amount to about another $1.5 million. Although a facility such as this would provide traffic service for trips from and to the Heights area, it does have the disadvantage of inducing additional traffic in the heavily used north-south corridor to downtown. However, this project was dropped from further consideration based solely on the excessive construction costs.

Design Criteria

Throughout this study, AASHO[1] and Interstate Design Standards were adhered to. From these criteria the typical sections shown on Figure 17 were developed. Section (a) is most suitable for existing streets that must be widened to 4 lanes. This proposed widening would in most cases involve no acquisition of additional right-of-way. Section (b) is best suited for streets, like Grand Avenue and 1st Avenue South, for which widening to 6 lanes is foreseen. Section (c) is to be used only for the proposed Rim connection via Zimmerman Trail and for the widening of State Highway 3, and State Secondary Highway 318 on the rim. Section (d) shows the proposed cross-sections that should be used for setting aside right-of-way for future streets in newly developing areas.

Cost Data

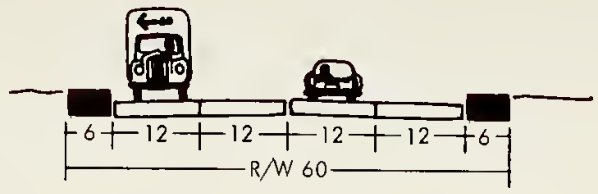
In the following chapter there is a summary of all cost elements for various projects that were investigated. Cost data is provided for both the projects that are recommended and for other projects that were studied in detail but were subsequently rejected. These costs are based on the assumptions as stated in this section of the report.

1 American Association of State Highway Officials.

Figure 17
Typical Cross Sections

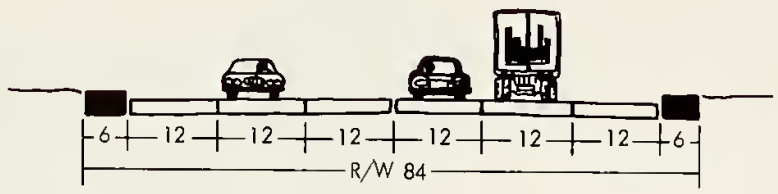
a

Arterial - 4 Lane in
Developed Area, No Parking



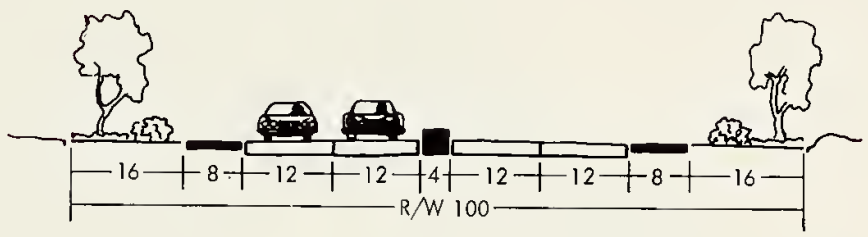
b

Arterial - 6 Lane in
Developed Area, No Parking



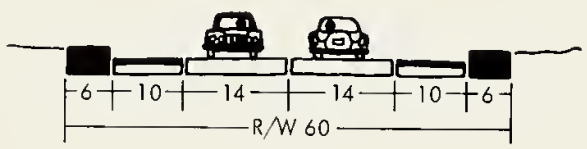
c

Expressway - 4 Lane,
Median and Shoulder



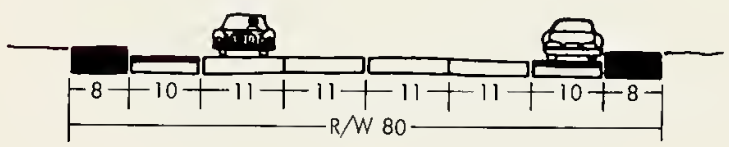
d

Collector - 2 Lane,
Parking



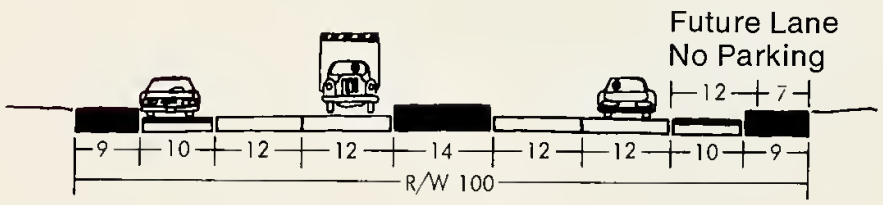
e

Collector - 4 Lane,
Parking



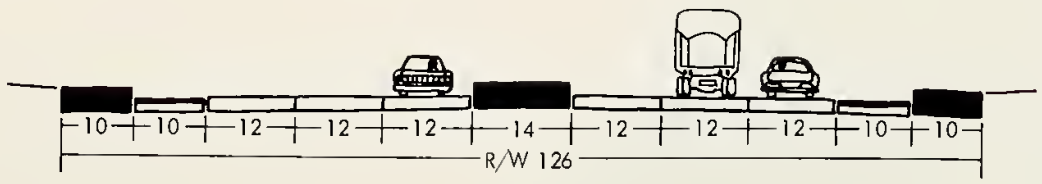
f

Arterial - 4 Lane,
Divided with Parking



g

Arterial - 6 Lane
Divided with Parking



7

Chapter 7

Recommended Network

The recommended system is a street and a highway network that will fulfill the major objectives outlined at the beginning of this study. These recommendations are the result of not only the technical studies described in this report, but also reflect the numerous discussions held with various interested committees in Billings. Most of the major features of this system have been reviewed and adopted by the Technical Advisory Committee, which as the name implies was concerned with the more technical details of this undertaking. Additional review and approvals were agreed to by the City-County Planning Board and by the Policy Coordinating Committee.

The description of the recommended system that follows is organized according to geographical areas (West Billings, Downtown, Heights, etc.), and by orientation and type of facilities (north-south, arterial and collectors).

Figure 18
Zimmerman Trail Improvement Plan and Profile

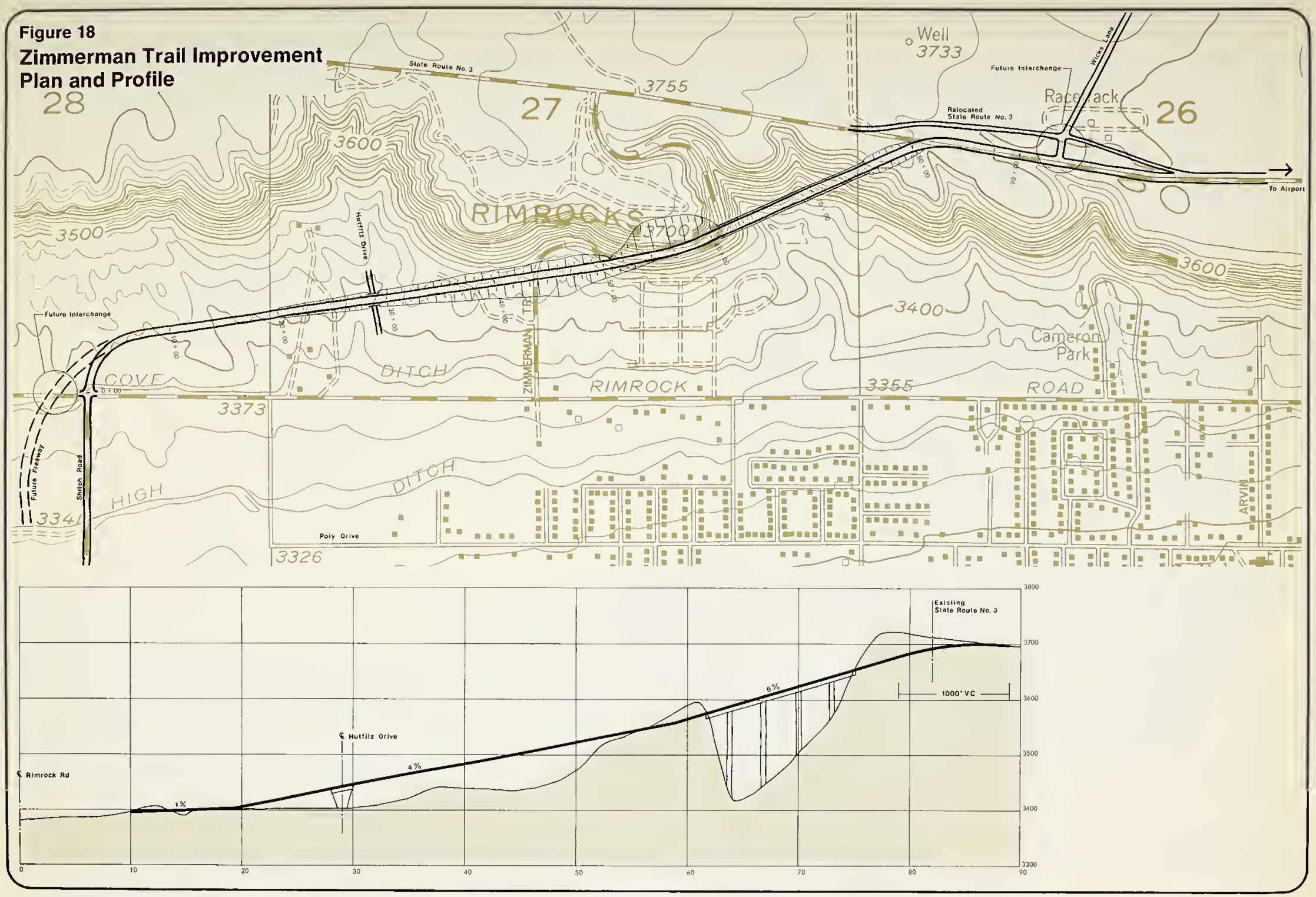
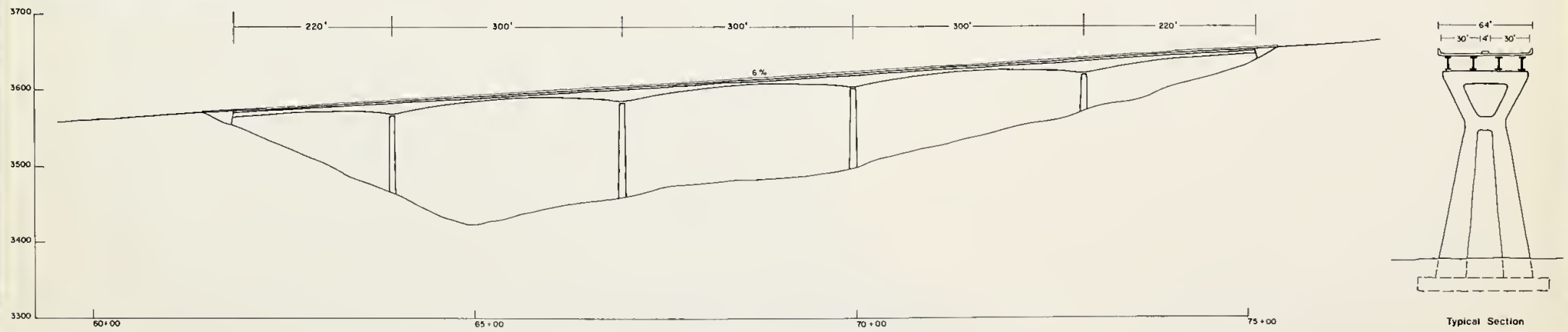


Figure 19
Zimmerman Trail Bridge Preliminary Design



Western Area, North-South Facilities

This area is assumed to include the section from 5th Street West to the study area west limit. Arterials between Niebauer Road and Rimrock Road are designated for 56th Street West and 48th Street West. In the case of 56th Street West, some alignment changes will be necessary at the intersection with Grand Avenue to provide a smooth transition to 56th Street West, in order to maintain a continuous route to Rimrock Road. Traffic demand on these arterials will be light even to 1990. Although the 60-foot cross-section shown in Figure 17(a) would be adequate, it is recommended to reserve right-of-way as shown in Figure 17(f).

An upgraded connection from Rimrock Road to Montana Route 3 in the general location of the existing Zimmerman Trail has been adopted by the Technical Advisory Committee. This route would utilize a portion of the existing Zimmerman Trail at the lower elevation, then by means of a structure, the gully in front of Wilshire Park would be bridged, providing direct access to Highway 3. The plan, profile and a preliminary bridge design is illustrated by Figures 18 and 19. The plan depicted in these exhibits differs somewhat from the alignment originally shown in the comprehensive plan in that the connection at Rimrock Road is assumed further to the west at Shiloh Road in this study. However, the basic concept of an improved connection to the Rim is the same. The advantage of this change is that the facility could be modified to tie into a limited access facility just west of Shiloh Road, should future volumes warrant it (probably post 1990).

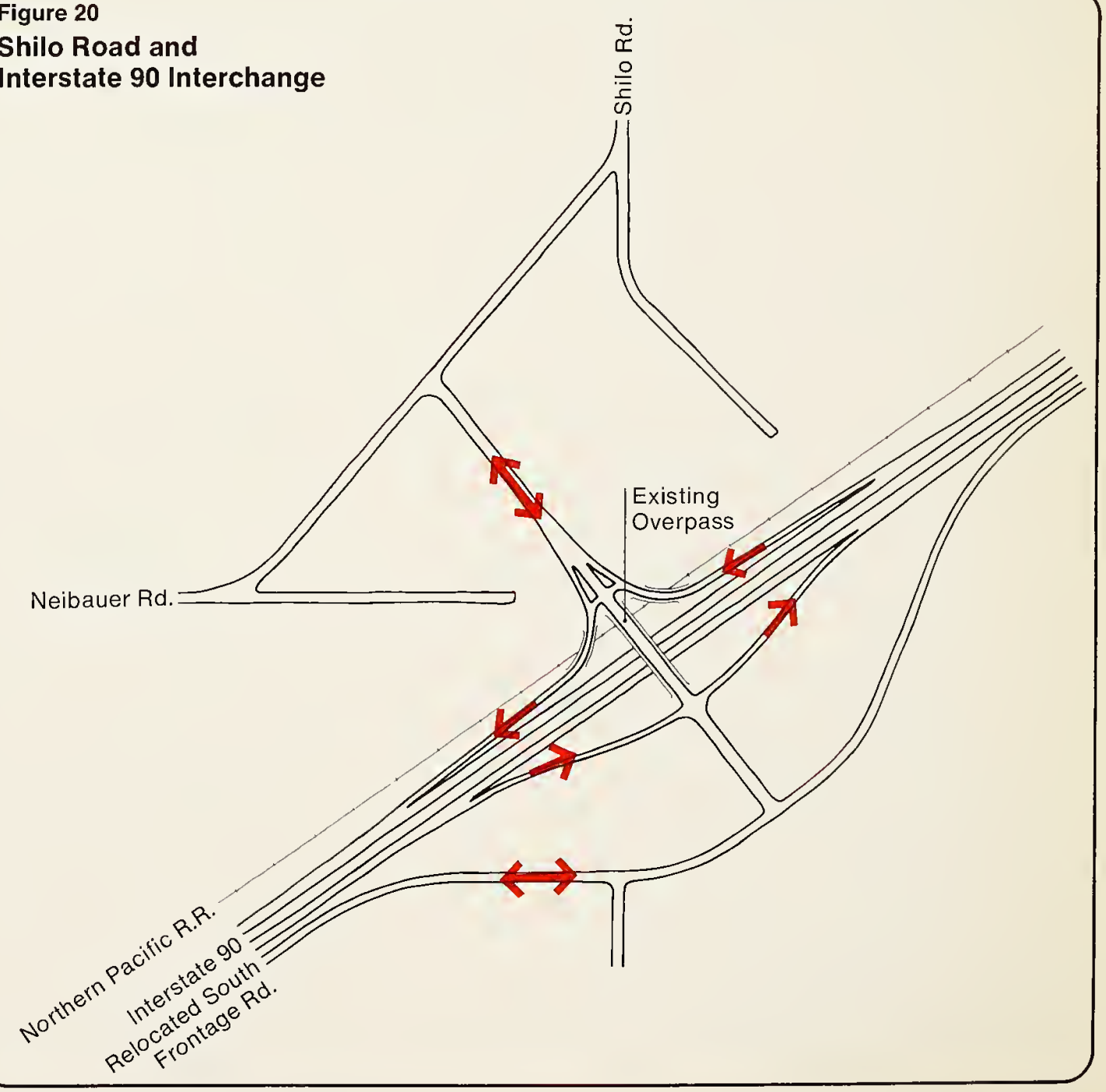
It is recommended that an interchange be provided from Shiloh Road to Interstate 90 to provide service to and from the west. The advantage of this plan is that it will provide the beginning of a loop circulation system around the west and north sections of the study area from the Interstate Route to Montana Route 3 via the new I 90 connection, Shiloh Road and the upgraded Zimmerman connection. Figure 20 illustrates a simple diamond type interchange between Shiloh Road and Interstate 90. This particular facility will provide good traffic service until some time in the distant future that more intensive development will require a full north-south freeway connection somewhere in this sector of the study area. At that time a higher type connection to Interstate 90 than the plan shown in Figure 20 will be required.

Inherent in these plans for a new interchange and connection to the Rims is the assumption of Shiloh Road as the major north-south arterial carrier in the western section of the study area. Projected 1990 volumes indicate that this route will need improvement between Grand Avenue and Rimrock Road.The recommended cross-section for the arterial in the relatively underdeveloped area is shown in Figure 17(f). Although traffic projections do not warrant much improvement for Shiloh south of Grand Avenue it is nevertheless suggested that right-of-way in this area be preserved for eventual widening.

Designated as collector roads are 36th Street West and 28th Street West between Hesper and Grand Avenue. The Comprehensive Plan also shows 36th Street West as being an arterial from Grand Avenue to Rimrock Road. However, a more detailed study by the Montana Highway Commission, in light of the relocation of the Zimmerman connection further to the west, indicates that this short section can be eliminated and its traffic functions be provided at Shiloh Road.

The next facility is 32nd Street West which is designated as an arterial between Hesper Road and Grand Avenue. Rehberg Lane provides the continuity to the north and is designated as an arterial between Grand Avenue and Rimrock Road. East of 32nd Street West the next arterial is 24th

Figure 20
Shilo Road and Interstate 90 Interchange



Street West from Hesper to Grand Avenue. 1990 traffic demand for this facility ranges from 4,000 to 8,000 average daily traffic which could be easily carried by the development of the existing 60-foot right-of-way. Again, it is recommended that right-of-way be reserved for eventual development to Sections 17(e) or (f).

Collector streets are designated at 19th and 12th-13th Streets West. This collector system would continue to Routes 10, 12 through Moore Lane. Seventeenth Street West would then become a major arterial from King to Rimrock. The proposed alignment would start at the intersection of King Avenue and 20th Street West, follow northeasterly to the intersection of Central and 16th Street West, follow 16th to Grand, and 17th Street West from Grand to Rimrock. Traffic analysis indicates that this facility should be four lanes from Central to Rimrock. The demand for the extended section between Central and King will be light and could be carried on two lanes, however, it would again be advisable to reserve sufficient right-of-way for an ultimate section as shown in Figure 17(f).

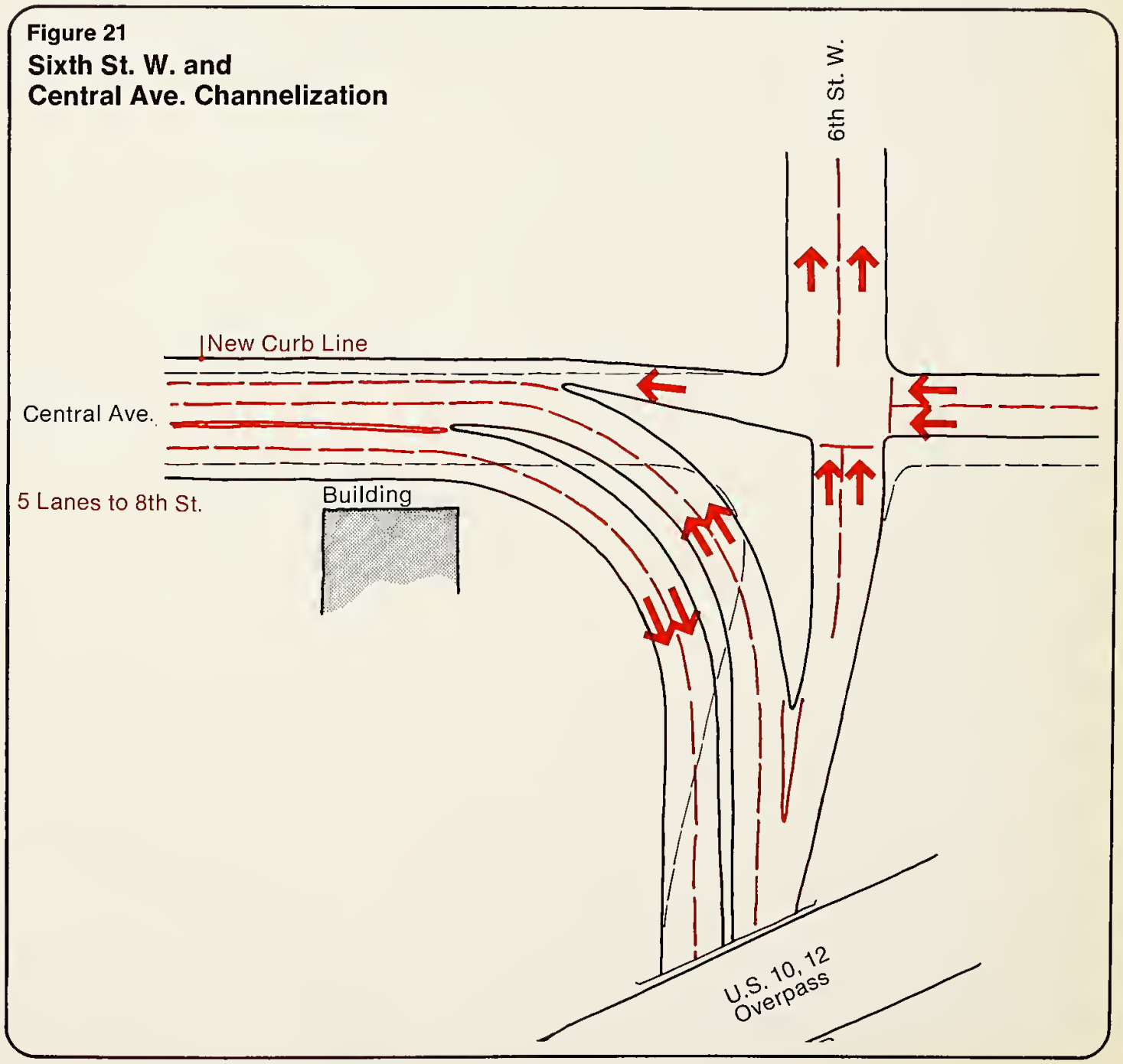
The section of 8th Street West, from Central to Parkhill Drive, has been designated as a collector road, 6th Street West, from Central to Poly, and 5th Street West from Montana to Rimrock, have been adopted as major arterials. The section of 6th Street West at the intersection with Central and the underpass under Montana Avenue is especially critical. It is this section which must carry a fairly heavy volume from Central to 1st Avenue South so as to reduce the flow on Montana Street.

Two possible geometric solutions for the underpass area have been studied. Figure 16 in the Signalization Study[1] shows one possible arrangement for the immediate future, while Figure 21 in this report presents a more long range solution. The concept illustrated in this report is to encourage the traffic movement from Central Avenue to 1st Street South at the expense of some minor moves that are provided for in the Signalization Study. The plan shown in this study should be implemented at the time when 1st Street South is improved to a major carrier. To maintain an orderly flow of traffic in this area, 6th Street and 7th Street West are recommended as a one-way, couplet system between Central and Broadwater, 6th Street to be northbound and 7th Street southbound.

The aforementioned arterials complete the major north-south system in the western sector of the study area. It is believed that this spacing of arterials and collectors will provide an efficient distribution of traffic in this locale.

1 Signalization Study for Billings, Montana
Clark, Coleman & Rupeiks Inc. Jan. 1969

Figure 21
Sixth St. W. and Central Ave. Channelization



Western Area, East-West Facilities

All of the five major east-west arterials will require some improvements or channelization and widening. The lane requirements outlined in this section are based on a connection to the Rims at Zimmerman Trail, and the assumption of Grand Avenue as generally the fastest east-west carrier in the corridor.

Rimrock Road should be four lanes from Pine Crest Drive to 38th Street West. This four-lane section is needed due to the induced traffic to the upgraded Zimmerman Trail and Route 3 bypass. In addition, Rimrock should be four lanes between 17th Street West and North 27th Street.

Poly Drive is recommended for four lanes between 17th Street West and Virginia Lane. A small couplet system has also been planned between Virginia Lane and North 30th Street, involving Poly Drive and Grandview Boulevard. This proposed layout is presented in Figure 22.

Grand Avenue is proposed as a six lane arterial from Division to 17th Street West, then four lanes to 24th Street West. This arterial is the prime carrier of traffic in this corridor.

Broadwater at present has four lanes between 12th Street West and Division Street. The current facility should be adequate to meet future traffic demands. The only improvements that may be advisable would be to widen the existing 11-foot lanes to the standard of 12 feet.

A short one-way couplet system on Broadwater and Custer Avenues is recommended to simplify the signalization on Division Street. This system should extend from Division Street to the 6th-7th Street West couplet system previously described. This will result in a more orderly flow around Division Street and provide an alternate route between Central Avenue and the Downtown couplet systems via 6th Street West and Custer for eastbound traffic and Broadwater Avenue and 7th Street West for westbound traffic.

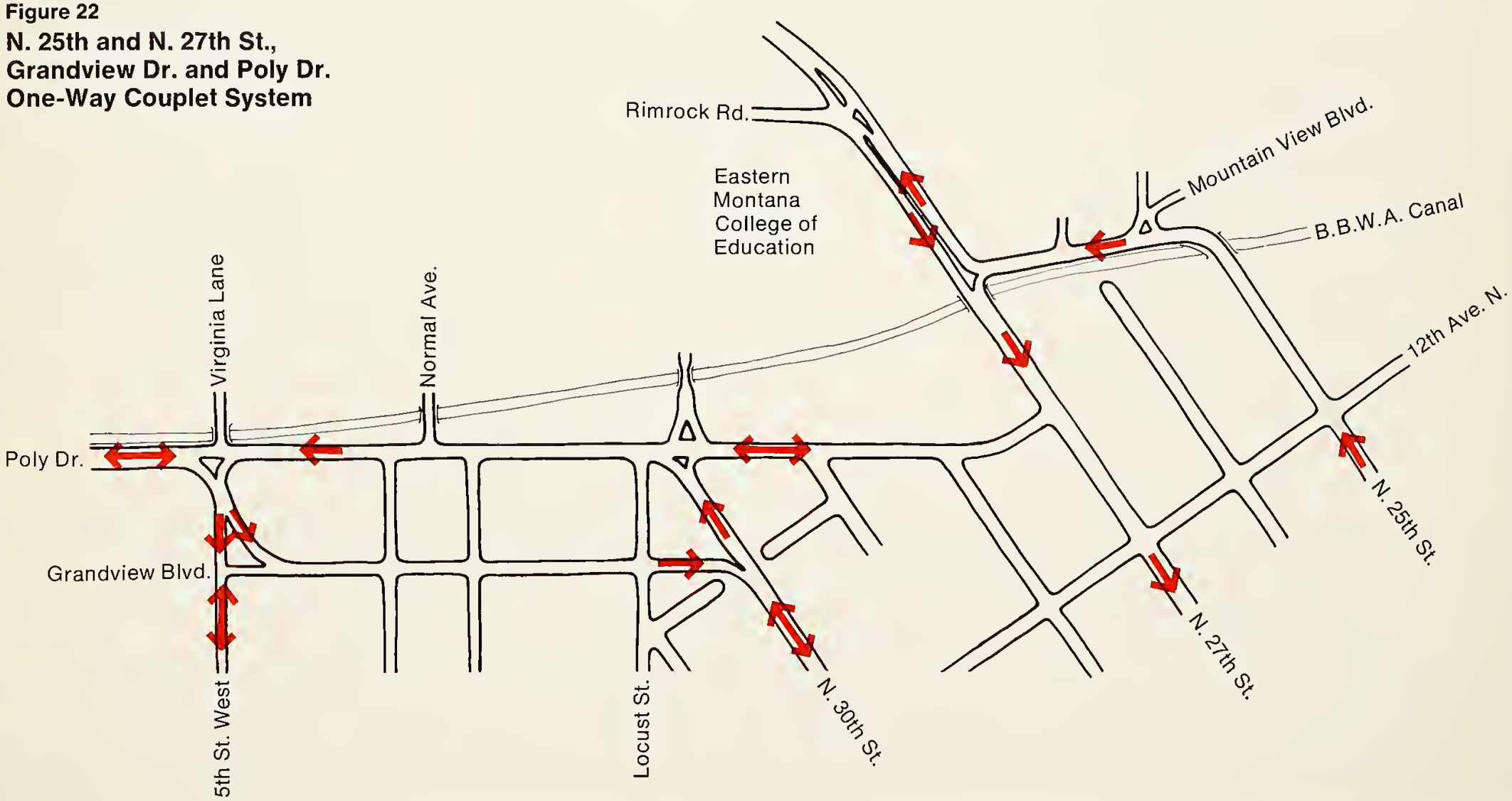
Central Avenue will generally require a four-lane section from 8th Street to 17th Street West. The intersection at 6th Street West was the subject of the more detailed study shown in Figure 21. In conjunction with this intersection improvement, a five-lane section will be needed between 6th and 8th Streets West, three lanes westbound and two eastbound.

King Avenue poses no great problems up to 1990. The only possible improvements that may be needed is some additional widening and channelization at the intersection with 24th Street due to a higher traffic demand to the West Interchange of Interstate 90.

The two remaining arterials of Hesper and Niebauer Roads are of a secondary nature. Traffic on these facilities will always be nominal. It is recommended, however, that right-of-way be preserved to eventually extend Hesper from Shiloh to 24th Street West.

The collector system in this area consists of Colton Boulevard, from 38th to 17th Street West, Parkhill Drive from 19th Street West to North Thirty-Second Street, and Monad Road from Shiloh Road to Moore Lane. The Monad Road collector will require a street extension between 32nd Street West and Shiloh, and a new bridge over the canal.

Figure 22
N. 25th and N. 27th St., Grandview Dr. and Poly Dr. One-Way Couplet System



The Central Area

This section of the network includes the street system between North 32nd-Division Streets and Exposition Drive.

Through this section of the study area, two major one-way couplet systems are proposed, Montana Avenue and 1st Avenue North for east-west flow, and North 27th and North 25th Street for north-south flow. Initially the 27th-25th Street system can terminate at 1st Avenue South. The recent reconstruction of South 27th Street makes this arterial adequate for the immediate future south of 1st Avenue South. Eventually this one-way couplet system will be extended south where it would be connected to 27th Street in the vicinity of 10th Avenue South. At the northern end of the couplet, North 25th Street would be extended over the canal to tie back into North 27th Street near the Eastern Montana College of Education.

Another recommended one-way couplet system is the Division, North 32nd Street system between Grand and Montana Avenues. This pair of one-way facilities will provide good circulation for traffic using Grand Avenue with origins or destinations in the Downtown Core area. For operational efficiency, it is also recommended that North 33rd Street be converted to a one-way southbound operation. By conversion of 33rd Street to one-way operation, considerable traffic relief will be afforded to the Broadwater-Division Intersection. The geometrics for this plan are illustrated in Figure 23.

In addition to these major couplet systems an ultimate one-way system for the downtown area is presented in the Signalization Study[1], Figure 6. The added features of this plan will complement the recommendations of this report. There are some differences in detail between the two plans in the area of Division Street. The plan outlined here tends to favor major traffic flows while the Signalization Report strives to preserve local access. Some of the details of the one-way system concerning the major arterials of 6th and 4th Avenue North will be subject to change depending on which new major facilities are adopted in the Fairground Area.

First Avenue South has been designated a major arterial. It is recommended that this facility be eventually widened to six lanes as shown in Figure 17(b) from the 6th Street Underpass to North 27th Street so as to relieve the future overloaded condition on Montana Avenue between Central and Division. It is also important that the improvement of 1st Avenue South be coordinated with North 27th-25th Street couplets to First Avenue South, so as not to create major turning conflicts at the intersection of 27th Street and 1st Avenue South.

Other streets that are designated as major arterials in this sector are North 30th Street to the Grandview-Poly couplet, State Avenue between 1st Avenue South and South 27th Street, and 4th Avenue North from Division Street to Exposition Drive. Sixth Avenue North is a major arterial extension of Grand Avenue, connecting traffic from Grand Avenue to the Fairground area.

Figure 23
Division St. and N. 32nd St. One-Way Couplet System

Billings Heights

This area is assumed to include the system from Emerald Drive to the north study area boundary. The major arterial system in this sector consists of U. S. Highway 87 and Wicks Lane. It is recommended that U. S. 10 and 87 be expanded to six lanes south of Wicks Lane. Wicks Lane should be four lanes at least between Lake Elmo Drive and Bench Boulevard. To provide an alternate access to the Heights area, it has been proposed to extend Wicks Lane to the west, around the north side of the airport, then southerly to connect with State Route 3 in the vicinity of Zimmerman Trail. It is also recommended to extend Glen Eagles Boulevard southerly to Alkali Creek Road. It has been additionally proposed to extend Hilltop Road to an intersection with the extended Glen Eagles Boulevard.

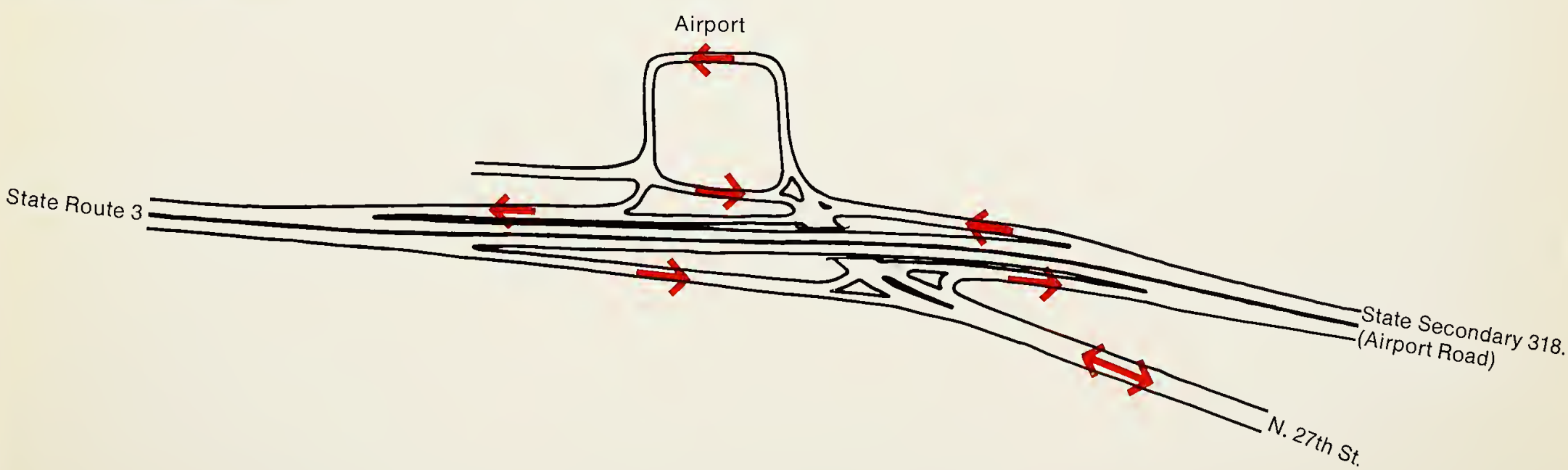
A portion of Alkali Creek Road between Glen Eagles Boulevard extended and Wicks Lane extended is shown as an arterial. Bitteroot Drive is shown as an arterial between Wicks Lane and U. S. Highway 87.

Lake Elmo Drive is designated as a collector road north of the intersection with Hilltop Road, the remaining portion of this facility to U. S. 10 and 87 is in the arterial system and should be widened to four lanes with channelization at the intersection with Route 87. Other collector roads in this area include Bench Boulevard, Hawthorne Lane, Yellowstone River Road, and Interlachen Drive in the north-south direction. East-west collectors are Five Mile Drive and Barrett Road.

Montana State Highway 3

Current traffic on this route ranges from about 1,500 to 2,500 vehicles per day. By 1990, due to the changed configuration of the highway network, this volume will increase tenfold. This route, with the improved connection at Zimmerman Trail and some additional east side connection to Interstate 90, will constitute the north link of a belt system around the urbanized area. It is recommended that this facility be upgraded to a four-lane divided expressway between Zimmerman Trail and U. S. 10 & 87. The volumes forecasted for this route will necessitate the construction of an interchange at the intersection with North 27th Street. A possible layout for this interchange is diagrammed in Figure 24. At grade intersections are assumed initially at the intersection of the Wicks Lane Extension, Zimmerman Trail and Montana Route 3. Ultimately an interchange may be required at this location if a west side freeway as shown in the Comprehensive Plan is built. Sufficient right-of-way is already available to accomplish most of the improvements described here.

Figure 24
Montana Route 3
N. 27th St. Interchange



Additional Access to Interstate 90

As previously described, the most critical area in terms of excessive traffic demand will be Exposition Drive, and Hardin Road between Exposition Drive and the Lockwood Interchange. Two possible solutions have been studied in considerable detail. One solution is to construct a freeway section parallel to Exposition Drive with a direct connection to Interstate 90. The other possibility is to build an expressway type facility from Route 87 to the Lockwood Interchange. The geometrics for these proposals are illustrated in Figures 25 and 26. Both of these plans have considerable merit and either of them would complete the arterial belt system around the west and north of the city. At this time, no firm recommendation is made on either of these possible solutions since there was not complete agreement between the Policy Coordinating Committee and the City-County Planning Board on this matter. Each of these proposals has its own advantages and disadvantages, and neither shows a clear cut superiority over the other. The Exposition Freeway has the advantages of providing good service for trips from and to the downtown area; it permits more direct routing between the Heights and westbound on Interstate 90; it allows good access around the Fairgrounds by preserving the existing Exposition Drive for local circulation; and it will divert enough traffic to negate the necessity for extensive improvements to the Yellowstone River Bridge on Hardin Road. The disadvantages are its higher costs, a new required interchange with the Interstate highway and some widening to the Interstate Bridge over the Yellowstone River to accommodate the merging connection from the Exposition Freeway.

The advantages of the Lockwood connection are its lower cost, its higher cost-benefit ratio, and the provision for direct service between the Heights, FAS 318 and Interstate 90 eastbound, and the Lockwood Area. The disadvantages of this route are that extensive channelization and signalization will be needed on Exposition Drive to provide for the downtown movement, and much work would be needed on the existing Lockwood Interchange to accommodate the traffic demand. An ordinary signalized system will not work, therefore the interchange ramp system must be revised and some of the other facilities in the area must be relocated as shown in Figure 26. Figures 27 and 28 depict the average daily weekday traffic in this general area for each of the alternates.

Figure 25
Exposition Freeway Geometrics

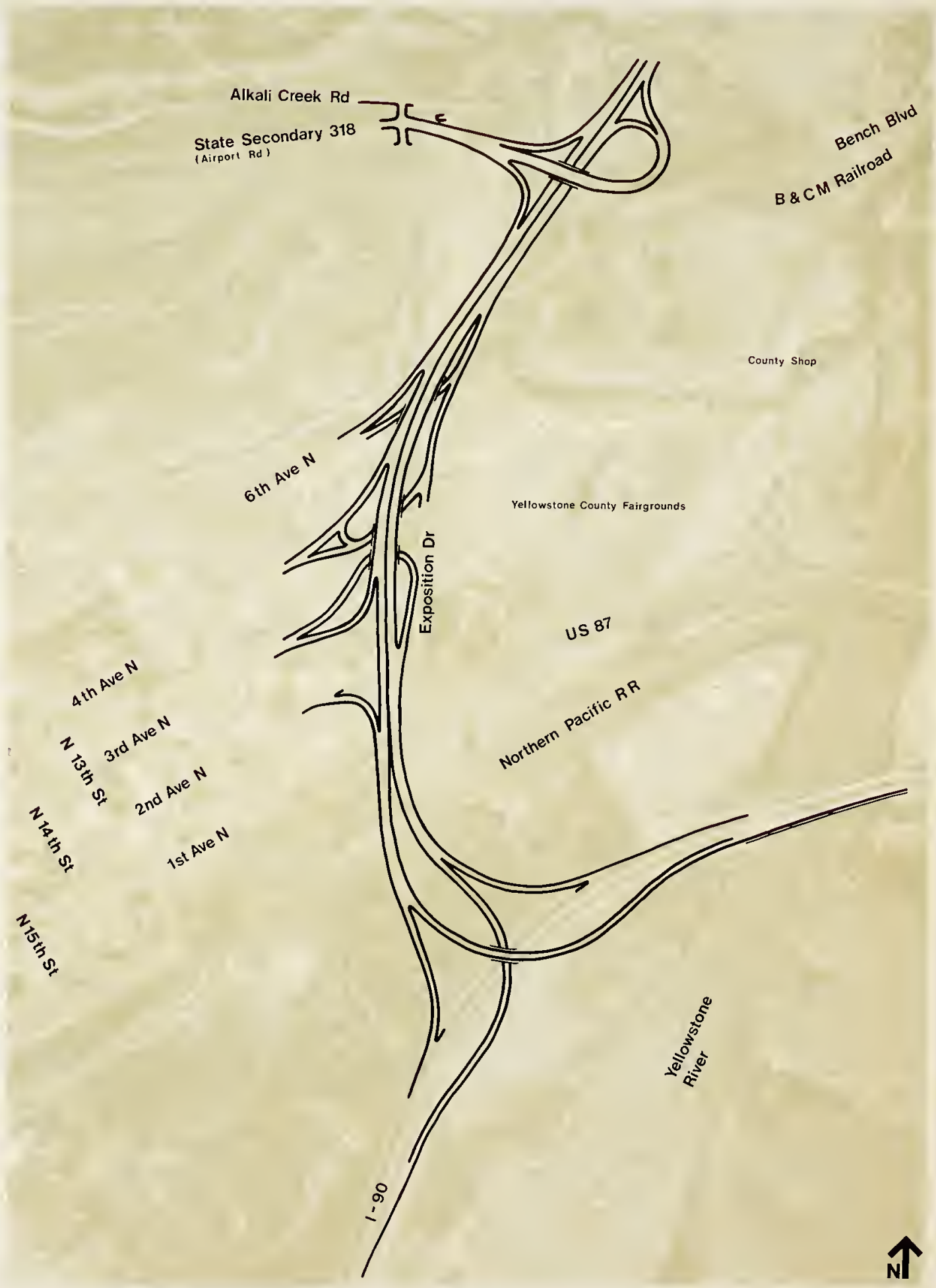
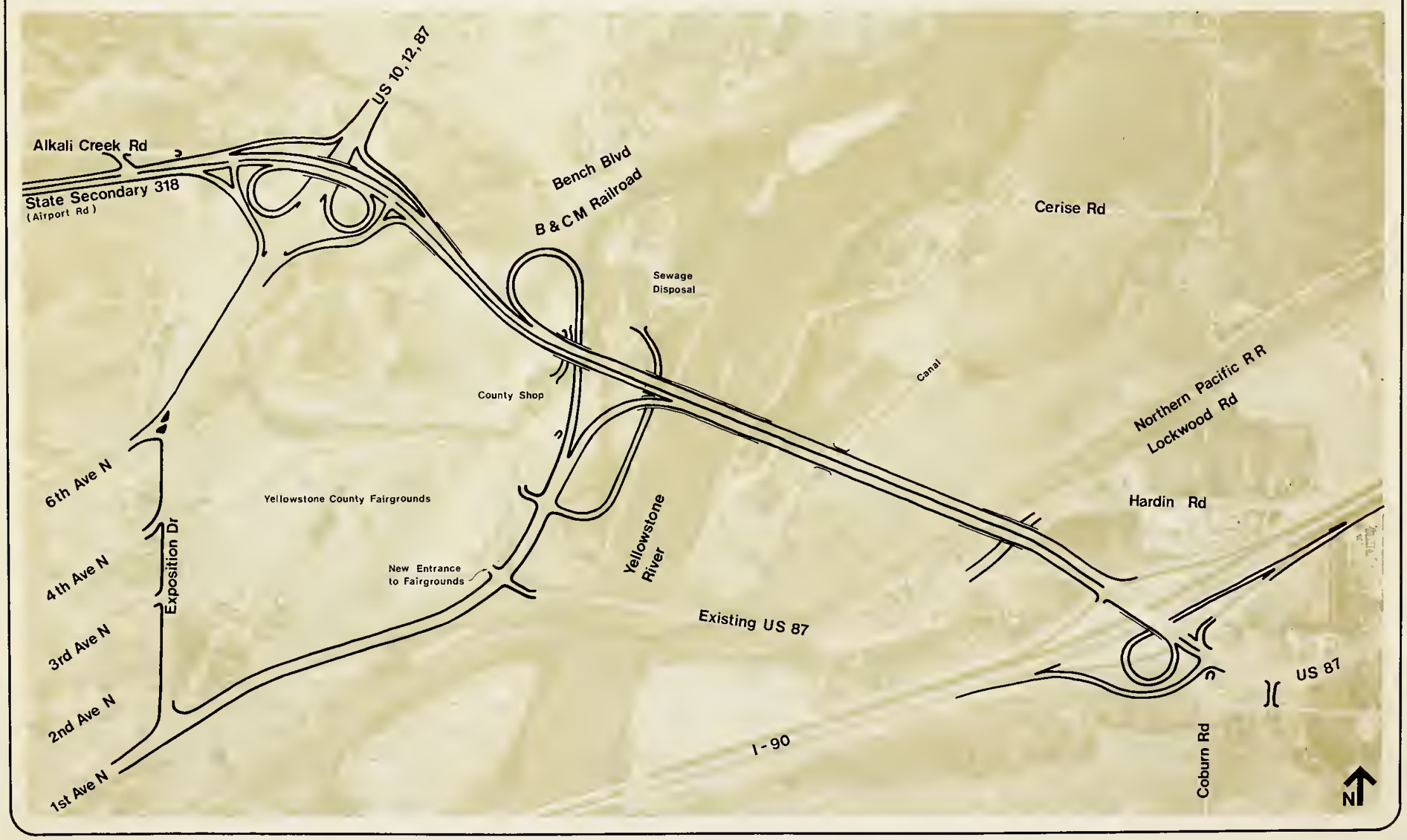


Figure 26
Lockwood Connection Geometrics



For presentation purposes the Lockwood connection is shown on the recommended system exhibit, however the final decision remains open pending a further small area analysis in conjunction with Fairground planning when this transportation plan is subjected to a review sometime within the next five years.

The aforementioned elements constitute the major physical features of the plan. Additional recommendations are included in this study to cover such items as widening, channelization and downtown circulation and parking demand. Figure 29 depicts the recommended network, broken down by Interstate, Primary, Secondary, Arterial and Collector Systems. Figure 30 presents a complete summary of areas of new construction, widening and channelization. The final two figures in this chapter illustrate the current (1966) average daily traffic on the existing network (Figure 31) and the future (1990) average daily traffic on the recommended network (Figure 32).

Figure 27
Exposition Freeway
1990 Average Daily Traffic

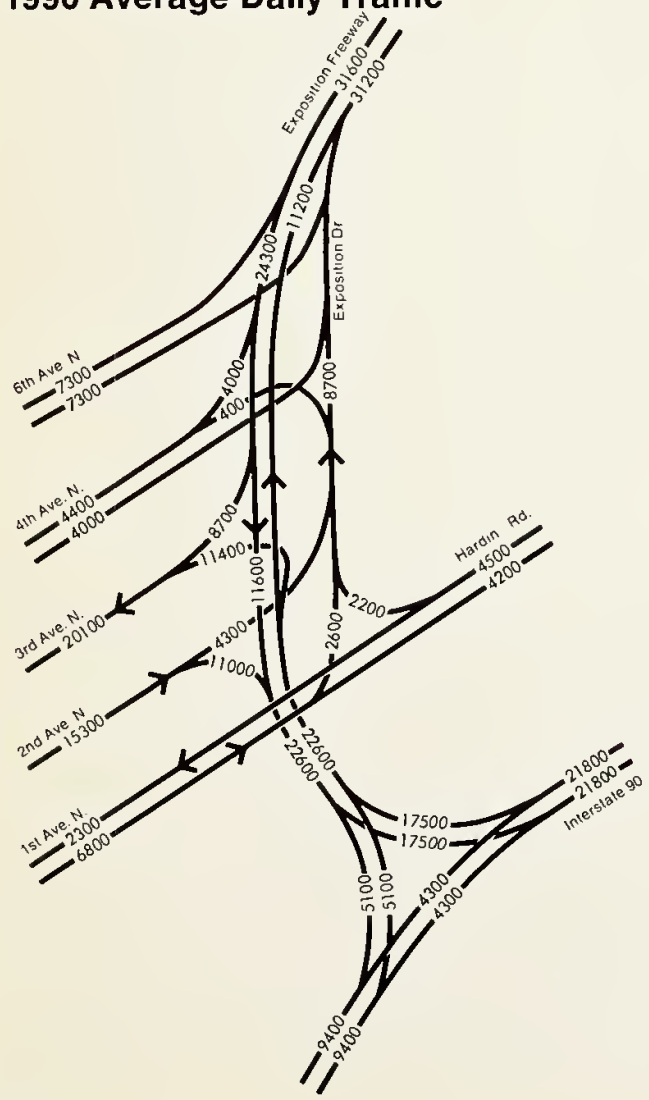
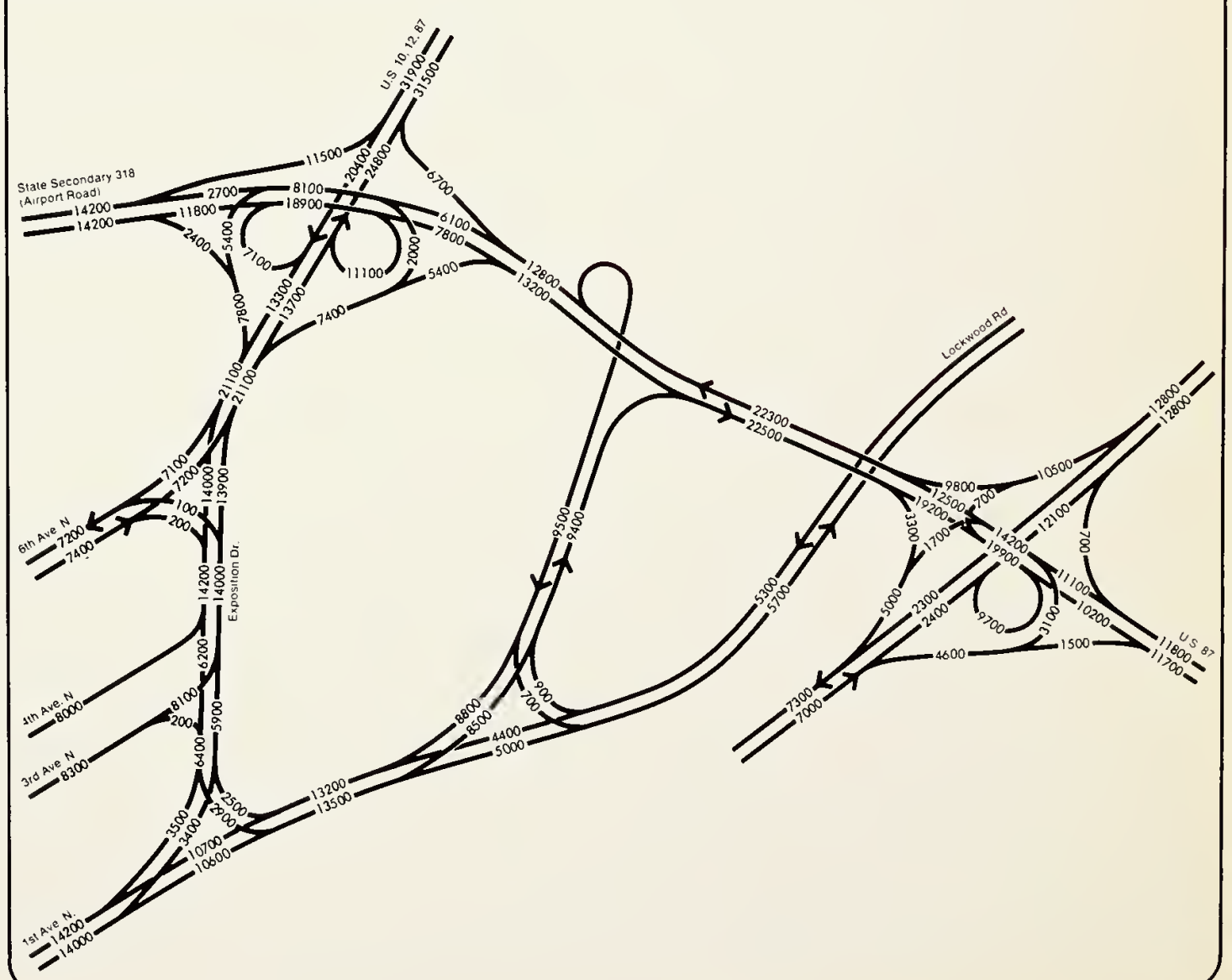


Figure 28
Lockwood Connection
1990 Average Daily Traffic



Railroad Relocation

In this study it has been assumed that the Northern Pacific Railroad would stay at its present alignment. If the railroad should be relocated, then additional features could be investigated for inclusion into the transportation plan. For example, a high type arterial could be constructed on the present railroad right-of-way to relieve the pressure on Montana Avenue. Such an additional arterial would probably mean that 1st Avenue South would need only four lanes rather than six. Another major benefit of relocation would be the easy extension of the couplet systems to the south, such as Division and 32nd Street which could be carried across and extended to State Avenue via 37th and 32nd Streets South.

Although relocation would have a major effect on traffic circulation in the downtown area, it would still not be considered desirable to delay any improvement plans pending a decision on the railroad removal.

Additional Projects Investigated

A number of projects were studied in detail but for a variety of reasons were rejected by the Technical Advisory Committee. Following is a list of these projects, their cost and the reason for deletion:

1. A projected connection from 17th Street West to the Rim was rejected because of the disruption of the existing residential development north of Rimrock Road, and the possible defacing of the cliffs as a result of the proposed highway. The estimated cost was about $3.2 million.

2. A tunnel connecting downtown Billings (near the intersection of 12th Avenue North and North 22nd Street) either with Alkali Creek Road or with State Secondary Route 318. Both plans were rejected because of their low traffic service and high cost. The connection with Alkali Creek Road would have amounted to about $15 million and the connection to State Highway 318, about $22 million.

3. A freeway-type interchange with interstate 90 east of the existing Shiloh Road overpass. This interchange was intended to serve as the beginning of the freeway loop that was ultimately planned for the City of Billings. Until the section of the freeway paralleling Shiloh Road was built, this interchange was to connect with 36th Street West. This street was to serve as an arterial connection between Interstate 90 and Zimmerman Trail. The plan was rejected because the interchange would be too elaborate for the near future, the existing Shiloh Road could provide the same function as intended for 36th Street West at a lower cost. A simple and more economical interchange could be built using the existing structure that would be easier to tie in a future freeway, if the new Zimmerman Trail expressway is aligned with Shiloh Road and not with 36th Street West. The cost of building 36th Street West as an arterial and the interchange with Interstate 90 would have been $5.4 million.

4. Improvement of Exposition Drive and Hardin Road. This plan called for an interchange of U.S. 10, 12, 87 with State Secondary Route 318, a partial interchange at the intersection of Exposition Drive, 1st Avenue North and Harding Road, and two new 4-lane bridges on U.S. 87, one over the Yellowstone River and the other over the Northern Pacific Railroad tracks. This plan had the disadvantage of being only a short-range solution for the traffic problems in that area of Billings. The plan did not provide a more direct connection to Lockwood nor to Interstate 90. The improvement in traffic service per dollar spent is not as large as that received by building the Exposition Freeway or the Lockwood connection. The cost of this project would have amounted to $5.9 million.

Figure 29
Recommended Network

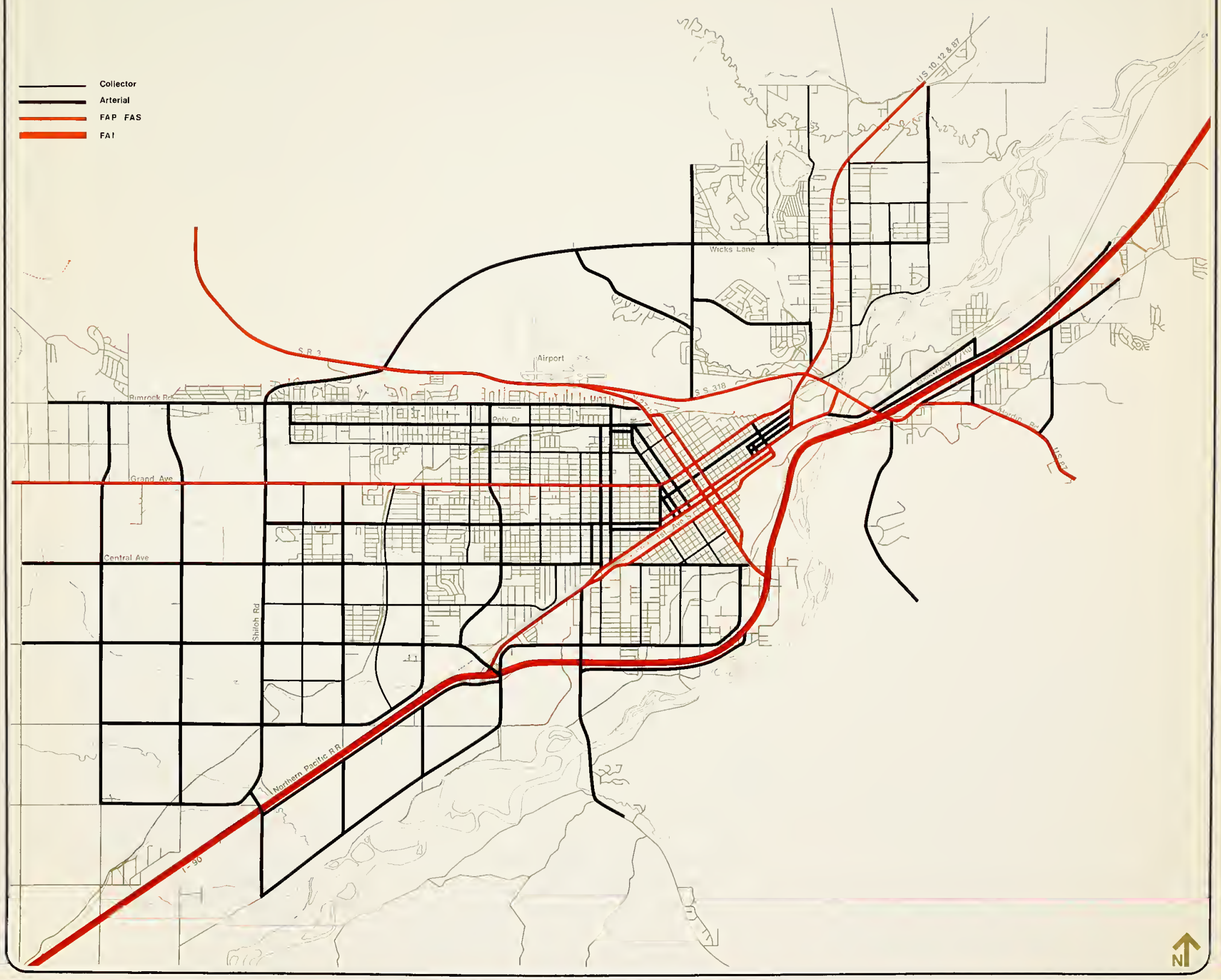


Figure 30
Areas of Widening Extensions and Channelization

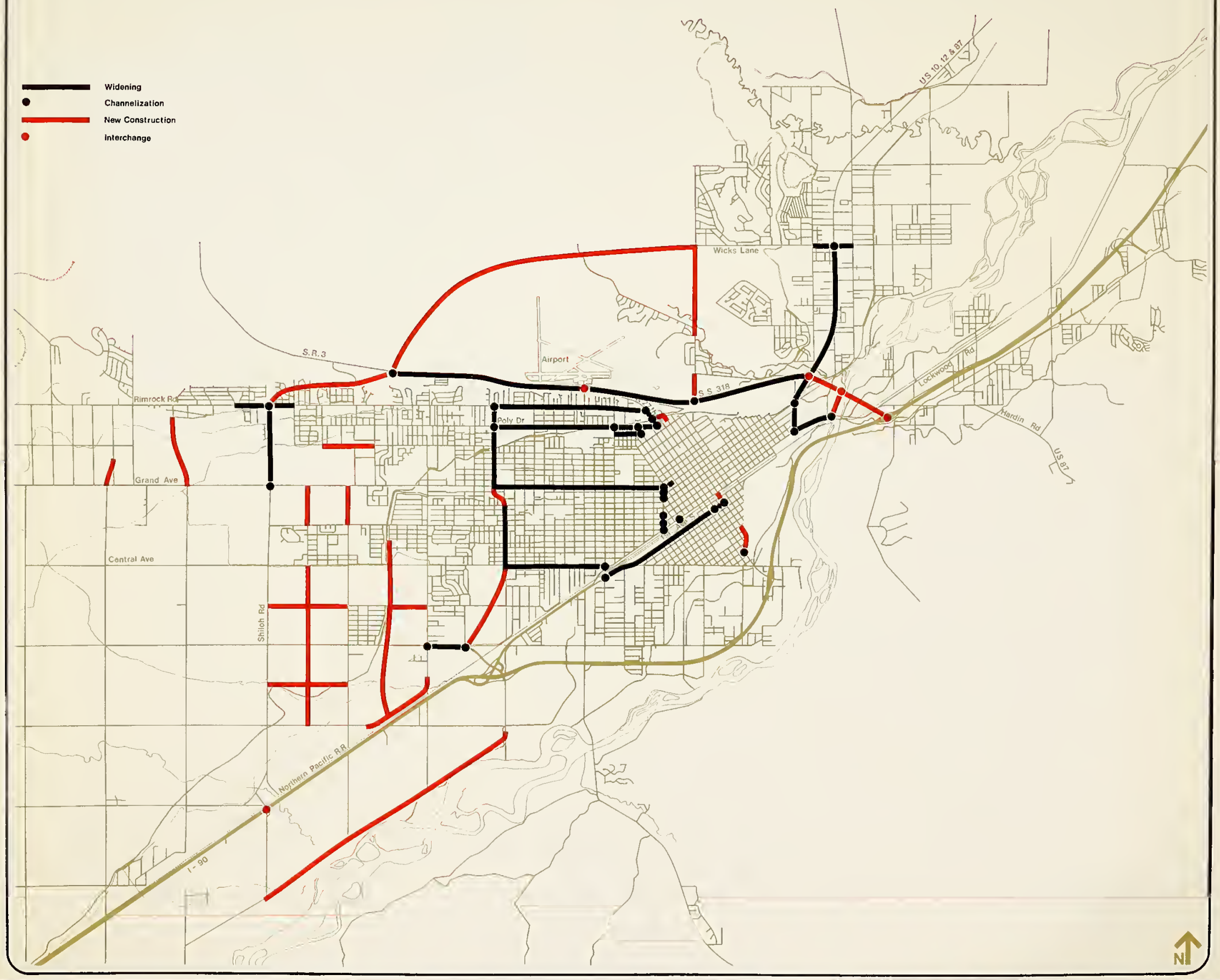


Figure 31
1966 Average Daily Traffic

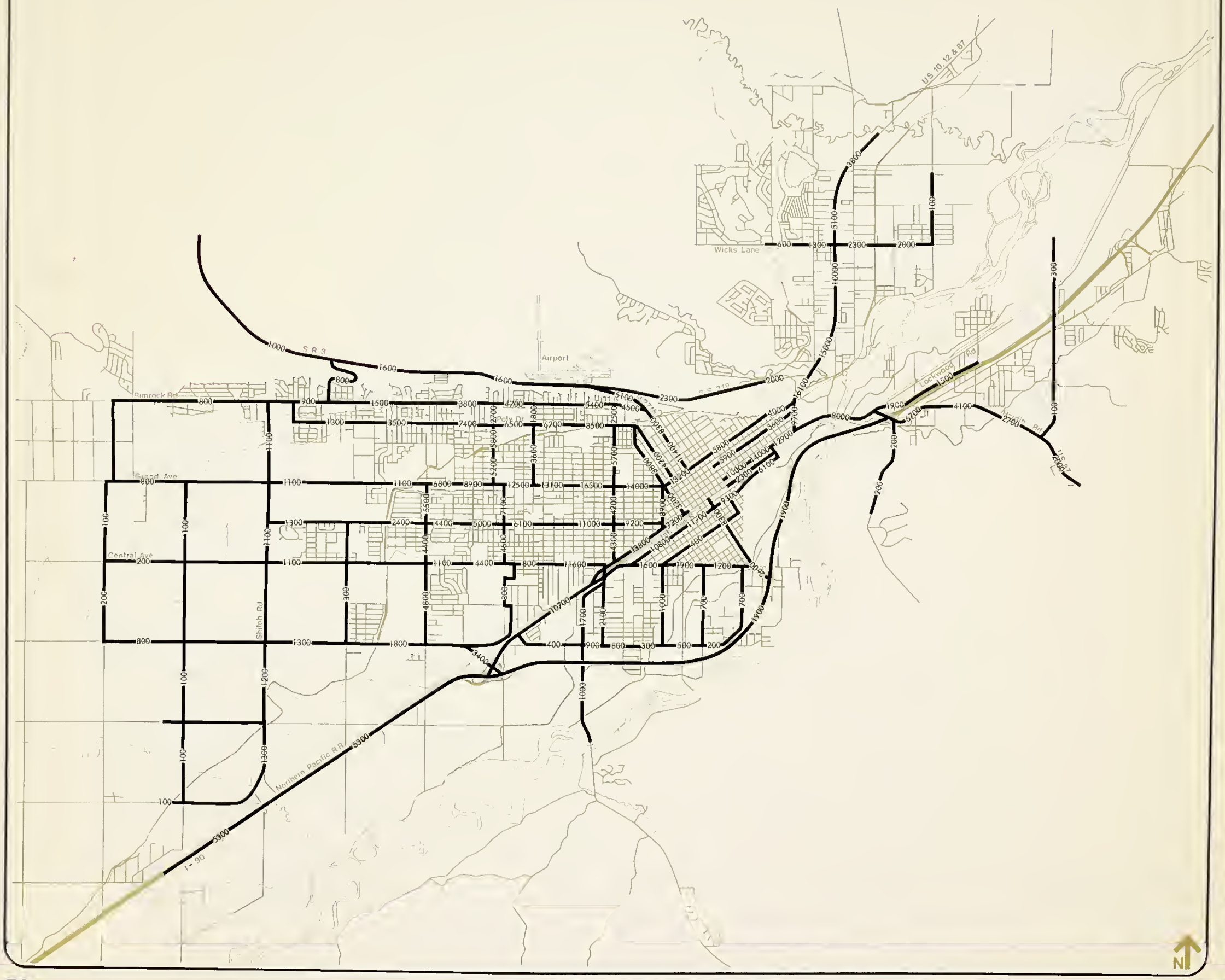
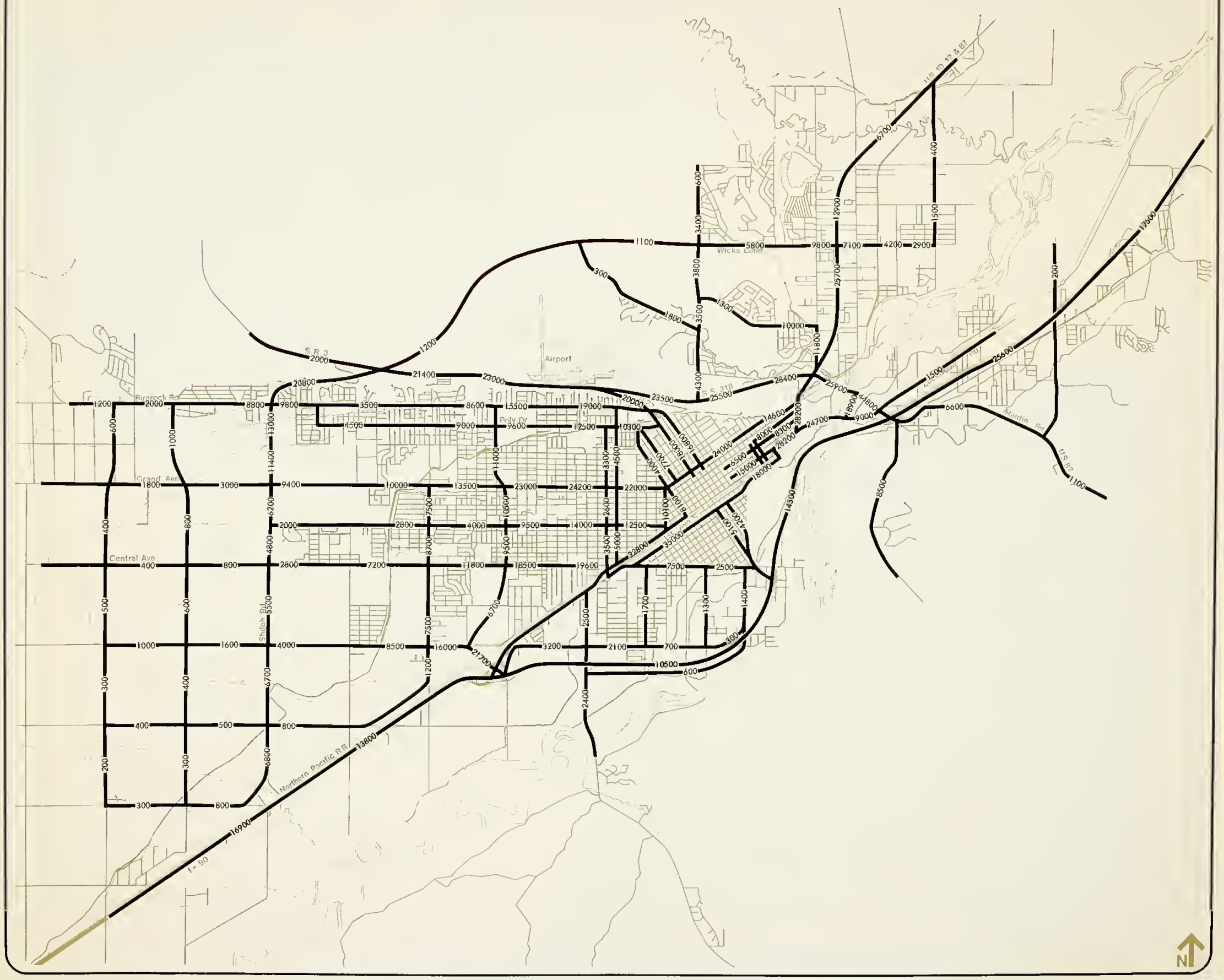


Figure 32
1990 Average Daily Traffic



8

Chapter 8

Financing

City of Billings

The City of Billings furnished us with data showing the expected revenues that will be available during the fiscal year 1969-1970 for construction. These funds will amount to about $306,000. The sources of this money are motor vehicle license plate fees and state gasoline tax revenues. An examination of Table 22 indicates that the city will need about $253,000 per year[1] to finance the local share of the improvements proposed in this report. It appears that the existing revenues will be sufficient to meet the required expenditures.

Money from the TOPICS program should further help the city pay for the needed improvements.

Yellowstone County

The county does not yet know exactly what its revenues will be for 1969-1970. For 1968-1969 it received about $774,000 for road and street purposes. The county budget does not distinguish between maintenance and new construction. Therefore, an estimate had to be made on our part as to how much money is available for new construction. We placed this figure at approximately $300,000. To construct all of the needed improvements recommended in this report, the county would require about $728,000 per year[1 2]. The result is a yearly deficit of about $430,000. Part of this will be covered by TOPICS. The exact amount cannot be determined at this time. It is certain that it will cover only a relatively small percentage of the total cost. Most of the deficit will have to be covered by the sale of general obligation bonds. A detailed financial study would have to be made to determine the exact magnitude of the bond issue. We would estimate it to be somewhere in the neighborhood of $15 million which would average to slightly over $20 per household per year over the 20-year period.

Over half of the county funds are slated to be spent on the improvement of Zimmerman Trail. Without that project a bond issue may not be necessary.

It should be emphasized that these costs are broken down according to current jurisdictions. It would seem reasonable to assume that should the plans proposed in this report be adopted, there would be some changes in jurisdiction for major facilities. At such time these cost allocations should be reviewed and updated.

1 1969 prices.
2 See Table 22.

Table 22
Estimated Cost of Recommended Improvements[1]

ON STREET(S)	BETWEEN STREETS		TYPE OF STREET[2]	ROADWAY WIDTH IN FEET: PAVEMENT PRESENT	PAVEMENT PROPOSED	RIGHT-OF-WAY PRESENT	RIGHT-OF-WAY PROPOSED	ESTIMATED COST IN THOUSANDS OF DOLLARS: CITY	COUNTY	STATE	FEDERAL
Priority 1 (0-7 Years)											
Montana Avenue and First Avenue North	Division Street	North 15th Street	2	40-60	40-60	74-80	74-80	$ —	$ —	$ 70	$ 130
North 25th Street and North 27th Street	Mountainview Boulevard	First Avenue South	2	53	53	80	80	—	—	215	415
Division Street, North 33rd Street and North 32nd Street	Grand Avenue	Montana Avenue	2	50	50	80	80	150	—	—	—
Grand Avenue	17th Street West	Division Street	3	50-60	72	60-80	84	—	—	780	1,520
First Avenue South	Sixth Street West	South 25th Street	3	32	72	60-80	84	—	—	330	650
Central Avenue	17th Street West	Sixth Street West	3	26-32	48-60	60	60-72	730	—	—	—
Broadwater Avenue	12th Street West	Division Street	3	44	48	70	70	130	—	—	—
Broadwater Avenue and Custer Avenue	Seventh Street West	Division Street	2	44	44-48	70	70	60	—	—	—
Seventh Street West and Sixth Street West	Broadwater Avenue	Central Avenue	2	40-60	40-60	70	70	50	—	—	—
Poly Drive	17th Street West	North 27th Street	3	25-38	48-72	60-80	60-80	1,500	—	—	—
Rimrock Road	17th Street West	North 27th Street	3	21-34	48	60	60	1,320	—	—	—
Poly Drive and Grandview Boulevard	Virginia Lane	North 27th Street	2	25-38	48	60-80	60-80	140	—	—	—
							Subtotal	$4,080	$ —	$1,395	$ 2,715
Priority 2 (7-14 Years)											
Zimmerman Trail	State Route 3	Rimrock Road	1	—	68	—	70-350	$ —	$ 9,160	$ 100	$ 200
Rimrock Road	Pine Crest Drive	38th Street West	3	30-32	48	60	60	—	360	—	—
Montana State Route 3	Zimmerman Trail	North 27th Street	1	32	68	80	80	—	—	680	1,330
State Secondary 318	North 27th Street	U.S. Highway 10, 12 & 87	1	32	68	80	80	—	—	380	720
U.S. Highway 87 (Lockwood Connection)	State Secondary Route 318	Interstate 90 or	1	—	68-80	—	130-230	—	—	2,370	4,630
Exposition Freeway[3]	State Secondary Route 318	Interstate 90	1	—	76	—	150-250	—	—	3,300	6,500
U.S. Highway 87	Wicks Lane	State Secondary 318	3	80	104	100	124	—	—	273	540
Wicks Lane	Bench Boulevard	Lake Elmo Drive	3	24-30	48	60	60	—	235	—	—
17th Street West	Rimrock Road	King Avenue	3	0-48	48	0-60	60-100	1,240	550	—	—
Shiloh Road	Rimrock Road	Grand Avenue	3	30-32	82	80	100	—	1,610	—	—
							Subtotal	$1,240	$11,915	$7,103	$13,920
Priority 3 (14-21 Years)											
56th Street West	Grand Boulevard	1,000 ft. N. of Grand Blvd.	3	0-30	48	0-80	100	$ —	$ 150	$ —	$ —
48th Street West	Grand Boulevard	Cove Avenue	3	0-30	48	0-80	100	—	300	—	—
Interchange	Interstate 90	Shiloh Road	1	—	—	—	—	—	—	490	930
South 25 th Street and South 27th Street	First Avenue South	Tenth Avenue South	2	0-68	40-68	0-80	80	—	—	130	250
Wicks Lane	Glen Eagles Boulevard	Zimmerman Trail	3	0	40	0	100	—	1,450	—	—
Glen Eagles Boulevard	Wicks Lane	Alkali Creek Road	3	0	40	0	100	—	400	—	—
36th Street West	Grand Avenue	Hesper Road	4	0	44	0	60	—	1,070	—	—
							Subtotal	$ —	$ 3,370	$ 620	$ 1,180
							GRAND TOTAL	$5,320	$15,285	$9,118	$17,815
							Average Per Year	$ 253	$ 728	$ 434	$ 848

1 Based on 1969 prices
2 1—Controlled access highway
2—One-way arterials
3—Conventional arterials
4—Collector streets
3 Alternative to Lockwood Connection. Cost was not included in total.

The TOPICS[1] Program

Some of the cost for improvements to the city and county street system can be paid for by TOPICS funds. The objective of this program is to develop a continuing program within an urban area designed to reduce traffic congestion and to facilitate the flow of traffic. The program is intended to maximize the efficiency of the existing street system. It does not contemplate major construction or reconstruction.

The following steps must be taken as a prerequisite to the approval of TOPICS construction programs:

1. A General Plan of highway improvements for the Billings urban area must be prepared based on the continuous comprehensive transportation planning process.
2. The city or county must first designate a preliminary Type II system. It is to be selected by the State in cooperation with local officials subject to approval by the Bureau of Public Roads Division Engineer.
3. An area-wide TOPICS plan must be approved. An important feature of this plan is the development of priorities of improvements within the study area for approximately the next five years.
4. Priorities must be established for all TOPICS projects within each study area.

Step (1) has already been taken. Once the remaining steps have been completed, or are underway and there is a reasonable expectation that they will be completed within the next 18 months, then the city and county will become eligible for TOPICS funds.

About $451,000 have been made available to the State of Montana for the fiscal years 1969-1970. How much a city such as Billings will receive remains to be worked out. Over the years this program could help pay for a considerable number of projects that would otherwise have to be paid for entirely out of local funds.

Following is a list of projects that would probably be eligible for TOPICS funds:

1. Division Street—North 32nd and 33rd Streets one-way couplet system.
2. Channelization of the Central Avenue-Sixth Street West intersection.
3. Widening the lanes on Broadwater Avenue from 11 to 12 feet.
4. Broadwater Avenue-Custer Avenue one-way couplet system.
5. Seventh Street West-Sixth Street West one-way couplet system.
6. Poly Drive-Grandview Boulevard one-way couplet system.
7. Elimination of jog on 56th Street West at Grand Avenue.
8. Elimination of jog on 17th Street West at Grand Avenue.

It is strongly urged that the city of Billings and Yellowstone County fulfill the necessary prerequisites for the TOPICS program as soon as possible so that they can participate fully in this program.

1 Urban Area Traffic Operations Improvement Program.

9

Chapter 9

Central Business District Parking and Circulation

Introduction

This section of the report examines parking specifically in the Central Business District of Billings, Montana, using the present conditions as the basis for projecting to the design year of 1990.

The expected growth of Billings between now and 1990 as reflected in employment projections, provided by the Planning Consultant, will impose a heavy demand on parking space in the CBD. This will be demonstrated in the following analysis.

Study Area

The study area encompasses 49 city blocks. It is bounded by North 23rd Street, Montana Avenue, North 32nd Street and 5th Avenue North, and is the same area studied by the previous De Leuw, Cather & Company study of the early 1960's. Figure 33 illustrates the study area limits, showing block numbers for reference to the parking inventory listed in Table 23.

Data Collection

The most recent parking space inventory data (Table 23) for the CBD was utilized in making this analysis. The present supply consists of 1711 long-term spaces and 4275 short-term spaces. Some changes in the uses of commercial loading space was made in the Spring of 1967 which permitted private automobiles to utilize these spaces **after** 11 A.M. This ostensibly increased the automobile parking space inventory by approximately 160 short-term parking spaces.

Employment projections to 1990 provided by the Planning Consultant indicates an overall increase in the various broad categories of employment classifications. The actual increase from 1966 to 1990 is 100 per cent from approximately 10,000 to 20,000 employees. These projections are shown in Table 24.

Analysis

The demand for parking space was based upon the CBD employment both present and projected, and was further subdivided into long-term demand (or employee demand) of over four hours duration, and short-term demand, customer, (or visitor demand) of up to four hours duration.

Table 25 indicates the factors and breakdown by each major employment classification which were used to determine the peak daily demand. The factors were derived from extensive past experience and research data for requirements of cities similar in nature and size to Billings.

Table 23
1966 Central Business District Parking Inventory

ZONE	BLOCK	CURB (Metered)	CURB (Other)	OFF STREET LOT	OFF STREET GARAGE	TOTAL
1	1	—	29	129	3	161
	2	—	31	110	4	145
	3	—	31	34	—	65
	4	13	27	90	4	134
	5	24	10	120	1	155
	6	34	—	237	17	288
Sub Total		71	128	720	29	948
2	1	22	10	154	—	186
	2	21	2	14	—	37
	3	7	6	97	—	110
	4	27	—	95	—	122
	5	32	5	64	2	103
	6	23	1	81	54	159
Sub Total		132	24	505	56	717
3	1	—	9	109	—	118
	2	—	22	41	—	63
	3	—	30	85	27	142
	4	7	23	154	3	187
	5	—	33	91	3	127
	6	—	38	44	8	90
Sub Total		7	155	524	41	727
4	1	15	26	19	6	66
	2	36	—	110	3	149
	3	33	—	201	—	234
	4	17	19	198	5	239
	5	33	—	45	56	134
	6	31	—	26	4	61
Sub Total		165	45	599	74	883
5	1	31	5	7	257	300
	2	29	1	40	2	72
	3	30	7	117	13	167
	4	31	5	21	—	57
	5	32	—	76	2	110
	6	22	5	38	68	133
Sub Total		175	23	299	342	839
6	1	16	19	84	—	119
	2	—	36	95	22	153
	3	—	41	80	4	125
	4	30	—	80	42	152
	5	11	20	32	7	70
	6	—	39	75	2	116
Sub Total		57	155	446	77	735
7	1	13	14	111	10	148
	2	28	1	53	5	87
	3	30	—	64	2	96
	4	5	8	—	—	13
Sub Total		76	23	228	17	344
8	1	34	—	10	—	44
	2	24	1	3	197	225
	3	24	16	72	—	112
	4	15	1	6	—	22
	5	11	—	—	—	11
Sub Total		108	18	91	197	414
9	1	27	2	34	—	63
	2	34	—	45	17	96
	3	9	27	69	7	112
	4	29	14	66	—	109
Sub Total		99	43	214	24	380
Grand Total		890	614	3,626	857	5,987

Figure 33
Parking Study Area

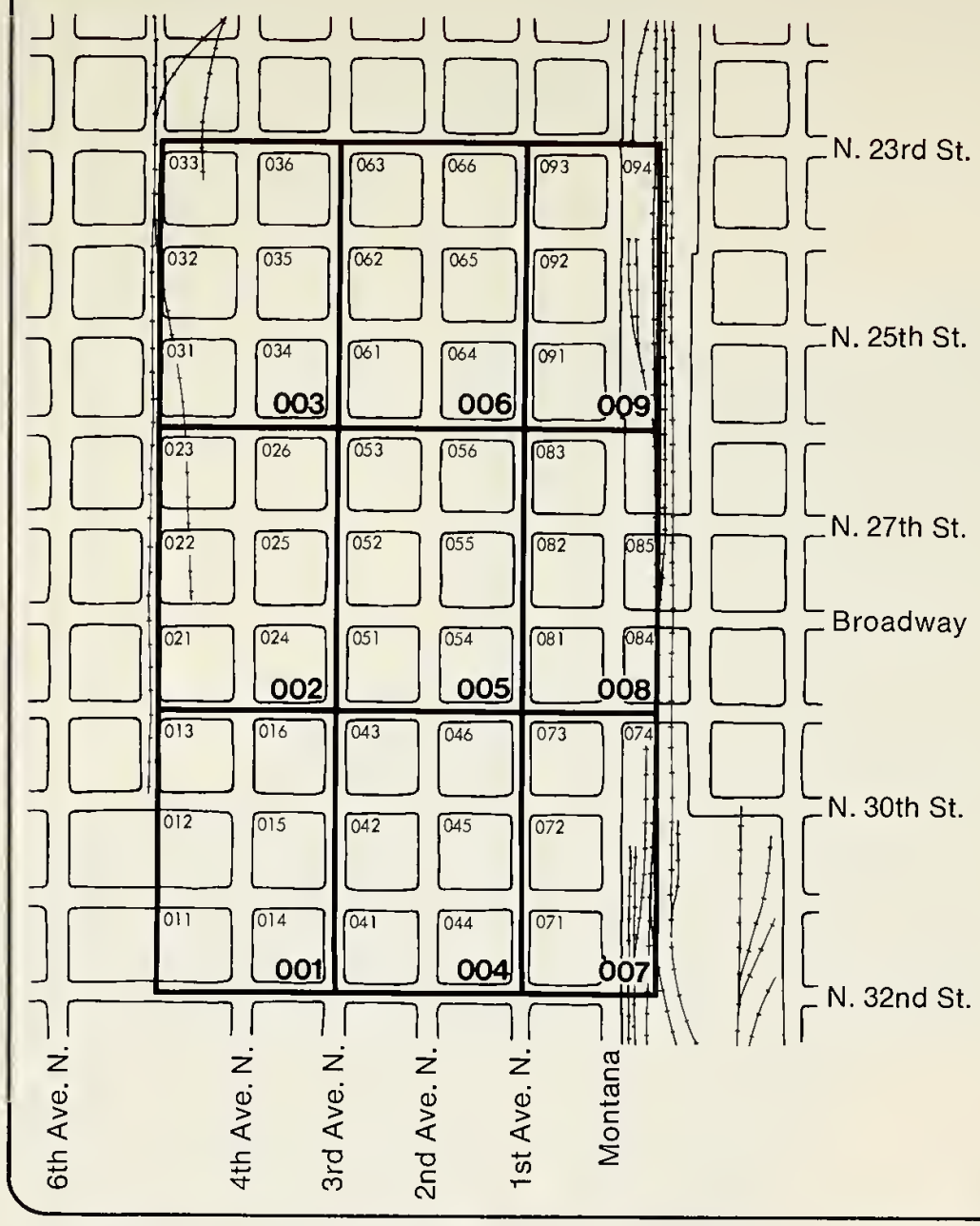


Table 24
Existing and Projected Employment for Central Business District

ZONE	1966 MFG.	1990 MFG.	1966 TRANS. UTIL.	1990 TRANS. UTIL.	1966 WHLSE. RETAIL	1990 WHLSE. RETAIL	1966 FIRE*	1990 FIRE*	1966 SERV.	1990 SERV.	1966 GOVT.	1990 GOVT.	1966 TOTAL	1990 TOTAL
1	14	14	0	0	128	220	64	290	210	400	0	0	473	924
2	0	0	66	185	126	220	360	1,580	159	300	1,024	2,400	1,973	4,685
3	4	4	0	0	33	65	2	10	9	20	116	280	280	379
4	0	0	318	850	287	550	29	110	35	60	0	0	761	1,570
5	94	94	206	560	793	1,430	266	1,180	412	785	1,245	2,895	3,451	6,944
6	1	1	0	0	111	210	24	100	18	30	4	10	180	351
7	10	10	66	185	235	430	15	80	30	60	0	0	405	765
8	271	271	78	225	346	630	69	290	507	960	556	1,315	2,078	3,691
9	1	1	78	225	182	350	5	20	79	150	2	5	394	751
											Grand Total		9,995	20,060

*Finance, Insurance and Real Estate

Table 25
Parking Factors

EMPLOYMENT CLASSIFICATION	LONG TERM PARKING SPACE DEMAND (employee spaces/ employee)	SHORT TERM PARKING SPACE DEMAND (visitor, customer spaces/employee)
Manufacturing	0.30 - 0.60	0.05 - 0.20
Transportation & Utilities	0.30 - 0.65	0.10 - 0.50
Wholesale & Retail	0.35 - 0.65	0.15 - 1.00
Finance, Insurance & Real Estate	0.50 - 0.85	0.20 - 0.78
Services	0.35 - 0.65	0.20 - 1.00
Government	0.30 - 0.50	0.04 - 0.12
Construction & Miscellaneous Trades	0.25 - 0.65	0.04 - 0.15

Results

Tables 26 and 27 summarize the results of these findings. There is a short-term surplus of 763 parking spaces at the present time which is increased by approximately 160 spaces when the commercial space parking becomes available at 11 A.M. The net result is a short-term surplus of approximately 900 short-term spaces, some of which could be utilized by long-term parkers. The employees in general would tend to utilize "free" parking in the surrounding residential areas.

The 1990 deficiency of 6168 long-term parking spaces is the result of increasing the employment density by 100 per cent. The short-term deficiency of 4627 spaces is the result of the natural growth of the CBD area. These large deficiencies of both long-term and short-term spaces are based upon the assumption that there would be no change in the parking supply from the present conditions. While this assumption is probably not accurate it does form the basis upon which an academic analysis can be made and which indicates the dramatic increase in demand for parking space as the city grows.

Table 26
1966 Parking Demand By Employment Categories

ZONE NO.	MANUFACTURING			TRANSP. & UTILITIES			WHOLESALE AND RETAIL			FINANCE, INSURANCE AND REAL ESTATE			SERVICES			GOVERNMENT			CONSTRUCTION			PARKING SPACE DEMAND IN 1966		PARKING SPACE SUPPLY IN 1966		SURPLUS ( ) DEFICIENCY 1966		ZONE NO.
	No. of Empl. 1966	L.T. 0.35	S.T. 0.08	No. of Empl. 1966	L.T. 0.30	S.T. 0.20	No. of Empl. 1966	L.T. 0.37	S.T. 0.65	No. of Empl. 1966	L.T. 0.50	S.T. 0.70	No. of Empl. 1966	L.T. 0.38	S.T. 0.80	No. of Empl. 1966	L.T. 0.30	S.T. 0.40	No. of Empl. 1966	L.T. 0.25	S.T. 0.00	L.T.	S.T.	L.T.	S.T.	L.T.	S.T.	
1	14	5	1	0	0	0	128	47	83	64	32	44	210	80	168	0	0	0	57	14	0	178	296	336	612	(158)	(316)	1
2	0	0	0	66	20	13	126	46	82	360	180	252	159	61	127	1,024	304	41	238	59	0	670	515	190	527	480	(12)	2
3	4	1	0	0	0	0	33	12	21	2	1	1	9	3	7	116	35	5	116	29	0	81	34	247	480	(166)	(446)	3
4	0	0	0	318	96	64	287	106	186	29	14	20	35	13	28	0	0	0	92	23	0	252	298	292	591	(40)	(293)	4
5	94	32	8	206	62	40	793	294	515	266	133	186	412	156	330	1,245	374	50	435	109	0	1,160	1,129	199	640	961	489	5
6	1	0	0	0	0	0	111	41	72	24	12	17	18	7	14	4	1	0	22	5	0	66	103	167	568	(101)	(465)	6
7	10	4	1	66	20	13	235	87	152	15	8	10	30	11	24	0	0	0	49	12	0	142	200	61	283	81	(83)	7
8	271	95	22	78	23	16	346	128	224	69	34	48	507	193	406	556	167	22	251	63	0	703	738	84	330	619	408	8
9	1	1	0	78	23	16	182	67	118	5	3	3	79	30	63	2	1	0	47	12	0	137	200	135	245	2	(45)	9
	395	138	32	812	244	162	2,241	828	1,453	834	417	581	1,459	554	1,167	2,947	882	118	1,307	326	0	3,389	3,513	1,711	4,276	1,678	(763)	

Table 27
Theoretical 1990 Parking Demand By Employment Categories

ZONE NO.	MANUFACTURING			TRANSP. & UTILITIES			WHOLESALE AND RETAIL			FINANCE, INSURANCE AND REAL ESTATE			SERVICES			GOVERNMENT			CONSTRUCTION			PARKING SPACE DEMAND IN 1990		PARKING SPACE SUPPLY IN 1966		SURPLUS ( ) DEFICIENCY 1990		ZONE NO.
	No. of Empl. 1990	L.T. 0.30	S.T. 0.05	No. of Empl. 1990	L.T. 0.45	S.T. 0.28	No. of Empl. 1990	L.T. 0.37	S.T. 0.72	No. of Empl. 1990	L.T. 0.50	S.T. 0.75	No. of Empl. 1990	L.T. 0.40	S.T. 0.80	No. of Empl. 1990	L.T. 0.33	S.T. 0.05	No. of Empl. 1990	L.T. —	S.T. —	L.T.	S.T.	L.T.	S.T.	L.T.	S.T.	
1	14	4	1	0	0	0	220	81	158	290	145	218	400	160	320	0	0	0	0	—	—	390	697	336	612	56	85	1
2	0	0	0	185	83	51	220	81	158	1,580	790	1,182	300	120	240	2,400	800	120	0	—	—	1,874	1,751	190	527	1,684	1,224	2
3	4	1	0	0	0	0	65	24	47	10	5	7	20	8	16	280	93	14	0	—	—	131	84	247	480	(116)	(396)	3
4	0	0	0	850	382	238	550	204	396	110	55	82	60	24	48	0	0	0	0	—	—	665	764	292	591	373	173	4
5	94	29	5	560	252	157	1,430	530	1,030	1,180	590	890	785	314	628	2,895	965	145	0	—	—	2,680	2,855	199	640	2,481	2,215	5
6	1	0	0	0	0	0	210	78	151	100	50	75	30	12	24	10	3	0	0	—	—	143	250	167	568	(24)	(318)	6
7	10	4	1	185	83	51	430	159	310	80	40	60	60	24	48	0	0	0	0	—	—	310	470	61	283	249	187	7
8	271	81	13	225	101	63	630	233	454	290	145	218	960	384	768	1,315	438	66	0	—	—	1,382	1,582	84	330	1,298	1,252	8
9	1	0	0	225	101	63	350	130	252	20	10	15	150	60	120	5	1	0	0	—	—	302	450	135	245	167	205	9
	395	119	20	2,230	1,002	623	4,105	1,520	2,956	3,660	1,830	2,747	2,765	1,106	2,212	6,905	2,300	345	0	—	—	7,877	8,903	1,711	4,276	6,168	4,627	

CBD Circulation

As has been noted in Chapters V and VII, the recommended system will provide efficient ingress and egress to the Central Business District through a system of one-way couplets and other improvements. In addition, this system provides enough alternate routes to keep non-CBD destined traffic out of the core areas.

Figures 34 and 35 are shown to illustrate in more detail the circulation demand in the interior core area system. Figure 34 is a summary of all existing traffic counts in this area. Figure 35 indicates the estimated 1990 demand. These 1990 volumes were derived from actual computer assignments, with some manual adjustments to eliminate certain distortions inherent in the traffic assignment program. This distortion is due to the necessary assumption that traffic in a six square block zone originates or departs from a single intersection.

As can be seen from Figure 35 the major traffic carriers are the two couplet systems and North 6th Avenue. The intersections of these arterials could develop into major problem areas in the future. To relieve this situation a number of possibilities are available, such as left-turn storage and right-turn only lanes. It may eventually be necessary to provide an additional traffic lane during peak periods by parking prohibitions during certain time periods. For example, a one-way arterial could provide three lanes of traffic during the off-peak period and four lanes during the peaks by the elimination of parking on one side. This could easily be accommodated within a 50′ to 60′ curb-to-curb width. In some cases it may only be necessary to eliminate a few spaces at the intersection approach to provide a turning lane.

From the traffic projections presented in Figure 35 an additional peak period traffic lane would be advantageous for both couplet systems. For example, if an approximate capacity calculation is made for the critical intersection of 1st Avenue North and North 27th Street the level of service for three one-way lanes with parking on both sides would be "E." The conversion of the approach arterials to a four-lane facility with parking on one side would raise the level of service to "D." The Capacity Manual[1] defines the "E" level as unstable flow with some congestion, while the "D" level is considered still in the stable flow area with no intolerable delays.

In general the circulation within the CBD area should always be at the "D" level or better. There will be some delays at high volume intersections but they will be considered tolerable. If the CBD area is to grow with the entire area and maintain its importance, a certain level of delay is to be expected. It would be economically if not physically impossible to attempt to provide a complete free flow system.

1 Highway Capacity Manual
Highway Research Board—1965

Figure 34
Central Business District
1966 Average Daily Traffic

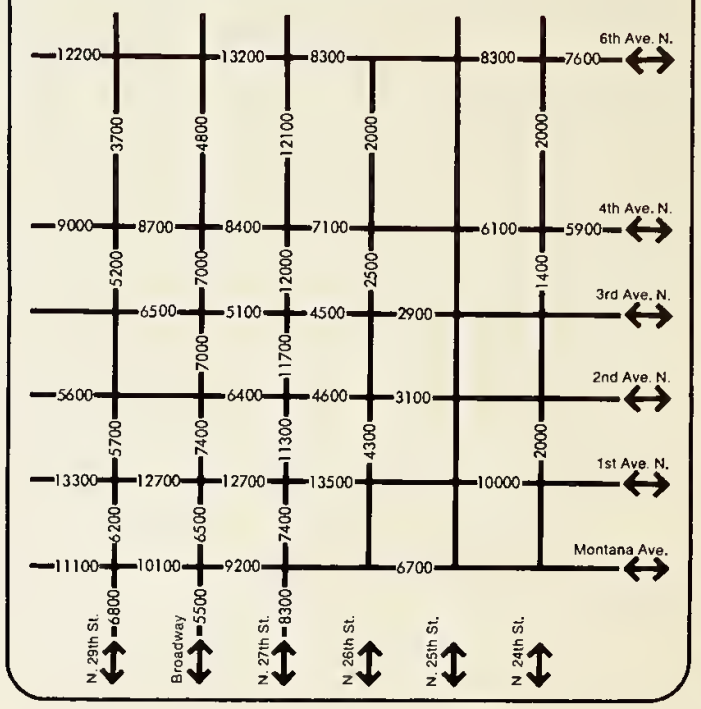
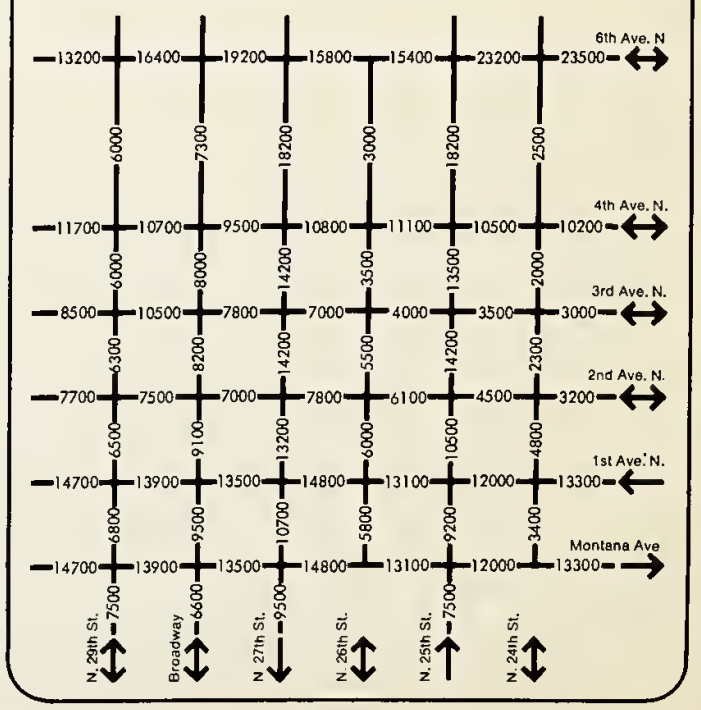


Figure 35
Central Business District
1990 Average Daily Traffic



Commercial Vehicles in the Central Business District

In 1966 the total number of trips by commercial vehicle to and from the Central Business District amounted to over 15,000. By 1990 this level of commercial vehicle activity should double. Currently 6,700 commercial trips have either an origin or destination in the core area bounded by the Railroad, 3rd Avenue North and North 29th-North 26th Streets. The presence of commercial vehicles has a two-fold effect in the central area, first they reduce available capacity for passenger vehicles, and secondly they utilize at times street parking areas for loading and unloading activities. At the present time there are restricted loading zones in effect between 9 A.M. to 11 A.M. It is possible that this activity could conflict with morning peak period circulation in areas where a temporary additional lane is needed to augment capacity, such as North 27th Street or 1st Avenue North. Screenline counts around the Central Business District indicate that the current morning peak hour occurs between 7 and 8 A.M. with only a slight drop-off of traffic between 8 and 9 A.M. Based on future employment projections, it is expected that this peaking characteristic between 7 and 9 A.M. will at least be maintained in the future. Therefore, when the growth of peak period traffic warrants an additional curb lane for traffic, the need will undoubtedly be between the hours of 7 and 9 A.M. This should not present much difficulty to loading activity since the maximum accumulation of trucks in the Central Business District occurs between 10 and 10:30 A.M. A recent survey by the City Engineer indicates that very seldom are these loading areas completely used between the hours of 8 and 11 A.M. Given the expected 81 per cent increase in wholesale-retail activity in the core zones of 5 and 8, it can be anticipated that these loading areas will be more fully used in the future. Some additional space in the North 27th, 28th Street and 3rd Avenue North area as well as an extension of the restricted time to noon or 1 P.M. may be necessary. The City Engineer's report indicates that these areas are currently being fully utilized prior to 11 A.M.

Transit Facilities in the Central Business District

A recently completed transit study[2] for Billings has presented three possible transit plans for community consideration. Since the Central Business District is the natural terminus for transit passengers, each of these plans provides service into this area either through a north-south or east-west corridor.

The anticipated volume of transit vehicle activity will not greatly affect the overall circulation in the central area, however, the location of stops can cause problems at individual intersections. The decision to locate a stop on either the near side or far side of an intersection can have an effect on both the transit vehicle operation and intersection capacity.

As a general rule the stop location is dependent on whether the vehicle is most likely to encounter a red or green signal at the intersection. If a green signal is most likely, then the stop should be on the far side. If a red signal is most likely, then the stop should be on the near side to combine loading and signal delay.

For the Billings Central Area it can be concluded that any routes utilizing the major couplet systems should have the loading-unloading areas on the far side. The couplet systems, as the prime traffic carriers, will usually have over 50 per cent of green time and they also lend themselves to a progressive signalization operation. Buses on secondary two-way arterials should stop on the near side to minimize delay. A near side bus stop can also be utilized as a right-hand turn lane when unoccupied.

A final element to be considered for stop locations is the ease of transfer where applicable. This consideration will have to wait until a definitive future transit system is selected by the community.

2 Transit Study for Billings, Montana
Clark, Coleman & Rupeiks, Inc.—January 1969.

Conclusions

To satisfy the increased demand for parking space in the CBD it will be necessary for the City to implement a planned program for parking garages. The most acute areas of shortage for both long and short term spaces occur in zones 2, 5 and 8 which includes the core area between North 29th and 26th Streets.

To maintain adequate circulation in the CBD the possibility of opening a curb lane for traffic during certain peak periods should be considered. This would especially apply to the couplet system to facilitate ingress and egress from the area as well as internal circulation.

The attraction of commercial vehicle trips to the core area will grow at about the same rate as other trips. There is a possible conflict between commercial loading and unloading activities and the installation of an additional curb lane for peak traffic. However, the peak period for this activity is generally after the A.M. traffic peak. Additional loading areas and an extension of the restriction past 11 A.M. will be necessary to keep pace with the growth in retail-wholesale activity.

After the future bus routes in the CBD are determined, some consideration should be given to the location of stops in relation to the intersection. Routes along high volume carriers where green time can be expected to exceed 50 per cent should have stops on the far side of the intersection. Routes along secondary arterials, where there is a greater probability of encountering a red signal, should have stops on the near side of the intersection.

Additional details pertinent to operational features of Downtown Circulation can be found in the Signalization Report. This report illustrates an ultimate one-way street pattern to augment the major couplet systems previously recommended for the Central Business District.

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